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Passive protection for industrial plants

Washington, D.C.

1942

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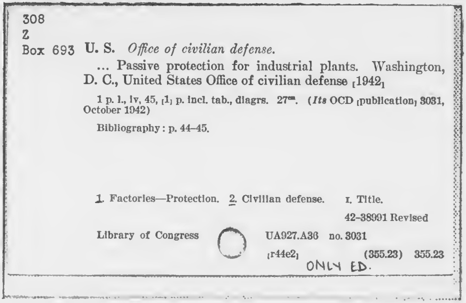

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PASSIVE PROTECTION FOR INDUSTRIAL PLANTS

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UNITED STATES OFFICE OF CIVILIAN DEFENSE
Washington, D. C.

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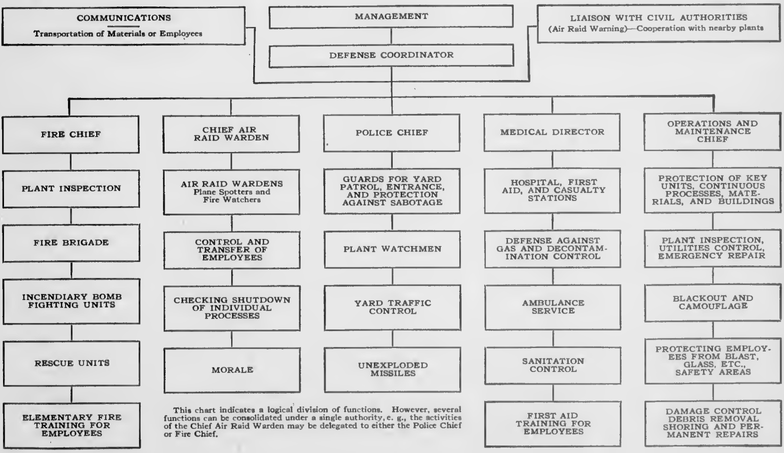
SUGGESTED ORGANIZATION CHART FOR PASSIVE PLANT PROTECTION


COMMUNICATIONS
Transportation of Materials or Employees
MANAGEMENT
LIAISON WITH CIVIL AUTHORITIES
(Air Raid Warning)—Cooperation with nearby plants
DEFENSE COORDINATOR
FIRE CHIEF
PLANT INSPECTION
FIRE BRIGADE
INCENDIARY BOMB FIGHTING UNITS
RESCUE UNITS
ELEMENTARY FIRE TRAINING FOR EMPLOYEES
CHIEF AIR RAID WARDEN
AIR RAID WARDENS
Plane Spotters and Fire Watchers
CONTROL AND TRANSFER OF EMPLOYEES
CHECKING SHUTDOWN OF INDIVIDUAL PROCESSES
MORALE
POLICE CHIEF
GUARDS FOR YARD PATROL, ENTRANCE, AND PROTECTION AGAINST SABOTAGE
PLANT WATCHMEN
YARD TRAFFIC CONTROL
UNEXPLODED MISSILES
MEDICAL DIRECTOR
HOSPITAL, FIRST AID, AND CASUALTY STATIONS
DEFENSE AGAINST GAS AND DECONTAMINATION CONTROL
AMBULANCE SERVICE
SANITATION CONTROL
FIRST AID TRAINING FOR EMPLOYEES
OPERATIONS AND MAINTENANCE CHIEF
PROTECTION OF KEY UNITS, CONTINUOUS PROCESSES, MATERIALS, AND BUILDINGS
PLANT INSPECTION, UTILITIES CONTROL, EMERGENCY REPAIR
BLACKOUT AND CAMOUFLAGE
PROTECTING EMPLOYEES FROM BLAST, GLASS, ETC., SAFETY AREAS
DAMAGE CONTROL DEBRIS REMOVAL SHORING AND PERMANENT REPAIRS

This chart indicates a logical division of functions. However, several functions can be consolidated under a single authority, e. g., the activities of the Chief Air Raid Warden may be delegated to either the Police Chief or Fire Chief.

FOREWORD

Plant Protection includes both Passive Plant Protection and Internal Protection and Security.

Passive plant protection consists of the protection of production, personnel, property, materials, and products from the effects of air raids or other related emergencies. This pamphlet deals with such air raid precautions. It is an amplification of the principles set forth in "Protection of Industrial Plants and Public Buildings," issued by the Office of Civilian Defense in August 1941, based upon further developments and actual experience in the solution of the technical problems in the organization of proper Passive Plant Protection.

Internal protection and security includes those measures designed to prevent interruption or delay in production caused by such hazards inherent to manufacturing as fire, accident, espionage, and sabotage and to establish the security of confidential and secret information in the possession of private manufacturers. The precautions necessary to effect such protection are covered by the War Department pamphlet, "Plant Protection for Manufacturers," and by the Navy Department pamphlet, "Security for Industrial Plants."

The War or Navy Department exercises jurisdiction over the passive defense measures, and the internal protection and security of those plants producing important, essential, and critical supplies for war use, allocated to them in accordance with "Inspection Responsibility Lists." The recommendations for protective measures of plants not allocated to the Army and Navy are assigned to the Office of Civilian Defense.

This program of Passive Plant Protection should be adapted by each plant to its own need. Many of the more elaborate installations mentioned herein are designed for large plants, although the basic program is applicable to plants of any size. The technical details of certain subjects treated briefly, and of other subjects not included, are covered fully in various other planning guides, pamphlets, and handbooks by the Office of Civilian Defense of which a complete bibliography is included in this pamphlet.

The principles of decentralization, dispersion, and duplication of essential equipment are sound and should be followed. However, each industrial establishment, manufacturing plant, factory, textile mill or machine shop has peculiar problems, known to the owner and top executives, who are best fitted to inaugurate such a program.

Employees should contribute to the perfection of such plans by volunteering for defense duty within the plant. In this connection, the plant should be considered as having prior need for the services of its employees over that of the Civilian Defense organization in the local community. The close cooperation of employer and employee can be achieved by the formation of a joint Committee on Air Raid Protection in each plant, which is recommended.

In this connection, it is essential that employees not only understand the effectiveness of the preparations made for their safety in the plant but that they should know of the efficient manner in which their families and their homes are protected by the local Civilian Defense organization. This knowledge will assure both the employee and his family of the precautions provided for their safety, and should be of assistance in maintaining employee morale.

Protective measures for all plants should be integrated into those of the locality in which the plant is situated. In that way the full benefit of the local Civilian Defense organization will be received.

Management must accept the primary responsibility for plant protection. Successful protection of industrial plants depends largely upon the thought, preparation, organization, and training done *NOW*. Plans must be worked out carefully. Suitable personnel must be selected. Individual instruction, group training, collective drills, and constant practice are essential.

The uninterrupted production of war supplies and civilian necessities, the necessary protection of all manufacturing plants, especially of those in the neighborhood of war industries, and the safety of all workers will depend upon the completeness and efficiency of air raid defense preparations.

NOTES ON THE ORGANIZATION OF PASSIVE PLANT PROTECTION

Passive Plant Protection may be divided into two categories, namely: personnel management and discipline, and physical installations or construction. The personnel measures consist of organizing and training the five Services outlined herein. The major features of physical installations are also included.

In general the organization of plant defense follows closely the usual pattern of Civilian Defense in the community. A Defense Coordinator corresponding to the Commander, Citizens Defense Corps, is empowered to initiate, direct and control the entire organization. The Defense Coordinator may be assisted by Deputy Coordinators, who are second and third in command and whose duties may correspond in general with those of the Executive Officer and Controller, Citizens Defense Corps.

The entire system is controlled from a central headquarters, known as the Plant Control Room. Here all reports of damage to the plant are received and from here the various services are dispatched. Upon receipt of a preliminary air raid warning alert, the Defense Coordinator reports to this Control Room and directs the operations of the organization from this point. This warning is transmitted immediately to those employees assigned to preparatory defense duties, who take their stations and execute such precautionary actions as have been previously designated, without disrupting the work of the other employees. The general Alarm should be given only upon receipt of the Red Signal, unless other instructions have been received to the effect that production is not to be interrupted until actual attack is imminent.

Larger plants may be divided into Divisions, each in command of a Division Coordinator with a Division Control Room, in order to decentralize control. The basic subdivision of all plants is the Post. The Post areas may correspond to the various departments or can be established as required on the different floors. Each Post is under the direction of a Post Warden. Usually such positions can be filled by the foremen of the various departments, who should be given a large measure of responsibility for the areas commanded by them. Each Post has a central point from which reports of damage occurring within the Post area are dispatched to either the Division Control Room or to the Plant Control Room. Every Post should be as self-sufficient as possible, permitting it to function if the main Plant Control Room cannot be reached.

The five Services are similar to the elements of the local Civilian Defense structure and the duties assigned to each service correspond to the usual duties of such units.

Each Service should be in command of a Chief who is responsible for its operation and for the coordination of its activities with the other units. The training of employees should be conducted by the local Defense authorities according to the prescribed Office of Civilian Defense training courses. The instruction of each employee in the specific duties of his position must be carried on by his superiors in the plant. In large industrial organizations where there is a Director of Training, he should be duly enrolled and qualified by the local Civilian Defense authorities to conduct this training for the plant. All employees assigned to defense duties should qualify to wear the official insignia of the Office of Civilian Defense for the Service or Unit to which they are assigned, without use of the name of plant.

It is essential that the Defense Coordinator, his Deputies, Division Coordinators, the Chiefs of Services and others with Defense duties, should have sufficient time available from their regular work to enable them to give attention to and become proficient in these Defense duties.

The scarcity of materials and the present strategical situation indicate the necessity for completing the physical installations outlined in this pamphlet in successive steps. Equipment for the protection of sensitive points against short sporadic raids should be provided at once. Thereafter, other installations for complete protection should be effected as rapidly as possible. Dimout regulations should be considered in providing blackout equipment. Ingenuity and good judgment should be used in converting materials already at hand to the purposes outlined in this pamphlet.

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DUTIES OF THE DEFENSE COORDINATOR

The duties and responsibilities of the Defense Coordinator are such that he must have executive, administrative, and cooperative ability, be capable of making quick and accurate decisions under emergency conditions, be informed concerning approved protection measures for industry, have knowledge of industrial equipment and processes, and be fully appreciative of the need for maintaining production as well as for protecting life and property. In many cases the Plant Safety Director will be selected for this position.

The Defense Coordinator should consult with Federal authorities, the local Defense Council, local public officials and with neighboring plants, and then adopt a suitable plan. He will appoint Deputy Coordinators who are authorized and competent to assume his responsibilities during absence so that someone will be on duty or readily available 24 hours a day. These Deputies will be second and third in command and will have in addition certain, specific, administrative Defense duties. If necessary, he will also appoint Division Coordinators who will be in command of such Divisions as may be required, in the organization of the Plant Defense structure. It may also be desirable to appoint one person as Training Chief and to assign to him the responsibility for the training of the personnel in conjunction with the local Civilian Defense authorities.

NOTE.—Employees essential for key operations should not be selected for air raid duty if others are available.

A sufficient number of persons should be included on the Staff of the Defense Coordinator to assist him in his duties. Members of the Staff should be given copies of the personnel chart and floor plans with necessary explanation and instructions. Staff drills should be held frequently in order to ensure effective functioning in an emergency, drills being arranged at such times as will minimize interference with plant production. The distribution of printed instructions for Staff members may be desirable.

A survey of the plant and the preparation of a complete personnel chart and floor layout of the industrial unit is desirable, showing such items as: Posts, temporary shelter areas, exits and exit lights or markings, windows, elevators and stairs, fire escapes and corridors, fire hose, sand pails, extinguishers, location of valves controlling automatic sprinkler systems and other fire-fighting equipment, fire alarms, telephones, first aid stations, water, gas, and steam mains, transformers and power supply lines, switches and control devices, personnel stations, and the location of all key machines and processes needing special attention during emergencies.

The more important specific duties of the Defense Coordinator are as follows:

He should establish an effective emergency organization as outlined in the chart and as amplified in this section and in the remainder of this pamphlet.

NOTE.—Variations in the size of the industrial unit, its personnel, and other local circumstances may require a more detailed organization than specified herein or may require that two or more separately designated activities be undertaken by one section or individual. However, in all cases responsibility should be definitely assigned for each separate branch of activity shown under the chart headings for "Fire Chief," "Chief Air Raid Warden," "Police Chief," "Medical Director," and "Operations and Maintenance Chief."

He should set up an organization that will function effectively twenty-four hours each day, regardless of shifts, part-time operation, or shut-down periods.

To accomplish this, the following preparations are essential:

1. Arrangements to receive air raid warning signals and to notify the Staff and all employees.

2. Adequate provision for direct communication and auxiliary communication within the plant and with the local Control Center. Where there is no Control Center, it will be necessary to establish means of communicating with the local

Defense Council, the Fire Department, police, hospital and other civil services, etc., as necessary.

3. Immediate organization and training of personnel and procurement of suitable equipment.

During an actual raid, he should, by means of personal check and reports, make certain that the various Services are ready for action and that the following measures have been taken:

1. Blackout.
2. Necessary safety measures for machines, processes, and materials.
3. Shelter seeking.
4. Fire prevention (closing of fire doors, etc.).

COMMUNICATIONS

A positive, efficient, and dependable communication system that will provide contact with outside sources and within the plant, is vital to the operation of any Passive Plant Protection organization. The center of communications is the control point of the Passive Defense system in each plant and is known as the Plant Control Room.

Here all reports of damage to the plant are received and the necessary units dispatched. Reports of major incidents are transmitted from here to the local Control Center in order to obtain the assistance of the local defense organization.

The Plant Control Room should be situated in such a location as will provide maximum safety to the Staff and to the equipment. Arrangements are necessary for blackout and proper ventilation. Control charts and maps of the premises should be at hand. Complete information should be maintained at all times of the progress of any incidents. Colored pins or similar markers, placed on the map at each point affected, may be used for this purpose.

In large plants, subdivided into Divisions, Division Control Rooms, similar to the Plant Control Room are necessary. The extent of the equipment and facilities of such Division Control Rooms will depend upon the size and nature of each particular Division. Reports of damage within the Division will be received here and either cleared directly with the units assigned to the Division and then reported to the Plant Control Room or reported to the Plant Control Room for clearing, depending upon the method best suited to the requirements of the Passive Defense organization in each plant.

Telephone is the basic medium of communication; however, additional facilities must be organized and understood in order that, in the event of failure of telephone service, such auxiliary methods as cyclists, foot messengers, radio, police, and fire call boxes will be available for communication both within the plant and with the local authorities.

Arrangements must be made with the local Civilian Defense authorities to receive air raid warnings at all times either direct from the local Control Center or by means of a chain-calling system of communications. A central point, continually manned, must be established where such warnings will be received. In large plants, an unlisted line, used only for this purpose, is recommended.

Alarms must be established within the plant so that warnings can be transmitted quickly. In like manner the communications system must provide for the rapid transmission of damage reports from any part of the factory to the Division Control Room or the Plant Control Room.

Telephone communication with the various Posts in the plant should be available, using existing facilities where possible. Messengers should be ready in case of a break-down in telephone service. Each Post must report each incident promptly, giving the exact location, nature of the damage, estimate of casualties and all other information, in accordance with a simple form of report suited to the requirements of the plant. The Plant Control Room should maintain communication with each incident and should be prepared to summon the local town services as needed. Communication facilities must be available in the First Aid Stations and, if possible, in the shelters, as well as at the stations of the Services. In the event of a gas attack, a distinctive signal such as a gong or other percussion sound, not used to give any other warning, should notify the personnel of this additional hazard.

The importance of arrangements for and practice with auxiliary communications, including an emergency Control Room, should be emphasized.

FIRE SERVICES

In peacetime, fire is one of the principal causes of loss of industrial property and of interruption of production. During war, when industrial plants, materials, and production are vital to national survival, the hazard of fire is increased, not only because production is speeded up and long hours of operation are necessary, but also because industrial plants become major objectives of saboteurs and of incendiary and other bombing from the air.

In most industrial plants definite responsibility for fire prevention and extinguishment is properly placed upon one individual, who may be designated as the Plant Fire Chief. His functions are of first importance in the organization for air raid protection.

Authority

The Fire Chief must be given the wholehearted support of the plant ownership and management. He must have authority to compel, if necessary, the attention of production and maintenance superintendents, foremen, and others to the requirements for fire safety. He must have the opportunity to advise on fire-safety requirements in connection with new buildings, new equipment, and new processes or procedures before such new facilities come into being.

His jurisdiction and authority should be clearly defined and understood by him and by his plant associates.

It is essential not only that he be well informed in fire prevention and fire extinguishment, but that through his own good judgment, poise, and personality he shall be able to command the interest, attention, and cooperation of his superiors, his fellow officials, and the rank and file of plant operatives.

The special character of operations or materials used in some industries require special methods of fire extinguishment. In such cases, the local fire department should be fully informed of this fact.

When fire occurs, his should be the authority to direct fire-fighting operations until the arrival of the public fire department.

Duties

The Fire Chief must know every building and part of the plant under his care, its construction, its occupancy and the hazards arising therefrom, the means of access and egress, the protection provided and the protection needed, and the actions that must be taken upon the outbreak of fire to extinguish it effectively. He must ensure that, when fire breaks out, it will be immediately discovered and that there will arrive on the spot promptly the men who know how to handle the situation and have the proper equipment. He should, in cooperation with the Coordinator, appoint and instruct competent deputies and arrange for one to be on duty at the plant at all times when the plant is in operation (for important plants twenty-four hours a day). He should select the posts for fire watchers, in cooperation with the Chief Air Raid Warden.

More specifically, he should:

1. Be guided by the fact that early discovery of a fire is essential to easy extinguishment.
2. Where automatic alarm equipment is provided, see that it is properly maintained and regularly tested and that alarm signals are understood and properly heeded by watchmen and others.

3. Provide or arrange for suitable public and intraplant fire-alarm services and for instruction of the proper persons in their use.

4. See that strict cleanliness, proper waste disposal, and good order of occupancy are maintained.

5. Know through inspection and frequent reinspection the nature of the materials present, the operations to which they are exposed, and the special dangers of fire or conditions of fire arising out of the operations or storage.

6. See that proper control, insulation, and clearance are provided where fire heat or high temperatures are used.

7. See that hazardous liquids, gases, or other dangerous materials are stored and handled in accordance with safe practice.

8. Make certain that operations or storage involving marked danger of occurrence of fire or of rapidly spreading fire or explosion are surrounded by suitable cutoff walls or other barriers.

9. Secure and provide at hand, at specific locations, the special type of first aid fire extinguishing equipment best suited for the type of fire likely to occur and instruct and drill operatives in the use of this special equipment.

10. Provide and suitably dispose the special equipment for the handling of incendiary bombs.

11. Where private hydrants are provided, make sure that they are kept operative, accessible, and properly furnished with hose, properly threaded couplings, nozzles, washers, spanners, tools, ladders, hose reels, and other suitable equipment, ready at all times for instant use.

12. Have daily inspection of all fire appliances and daily check of all sprinkler control valves (individuals assigned to this duty may be alternated if feasible).

13. Inspect the entire plant once each week with respect to cleanliness, storage, and occupancy conditions, special fire hazards, provision and condition of first aid fire extinguishing equipment, hose and hydrant equipment, air raid equipment, sprinkler equipment, and water supplies, valve sealing, readiness of fire brigades, alarm equipments, watchman services, and all other features of fire protection, making operating tests where necessary to determine condition, and making written report and record of the inspection showing faults found and recommendations made.

14. Cooperate in weekly or other regular plant inspections with Division Managers, Foremen, Plant Police Official, Safety Director, Medical Officer, Air Raid Wardens, and others responsible for and interested in the various features of plant operation and security.

15. Cooperate with and take advantage of inspections by properly identified representatives of authorized outside interests, such as public fire and police departments and fire protection engineers of the insurance interests.

16. Inspect and maintain reserve water supplies.

Fire Brigades

The Plant Fire Chief should:

1. Train in the use of the first aid fire extinguishing equipment units of employees in each working shift in each room, building, or department, according to plant conditions.

2. Organize and regularly drill a plant fire brigade in the use of private fire protection equipment. Select personnel from different shifts so that an adequate number of men will be available at all times.

3. Arrange for suitable fire-alarm signals and other provisions to enable cooperative action of the fire-fighting squads and hose companies upon the outbreak of fire.

4. Arrange with the public fire department to familiarize officers and men of fire companies with the plant conditions, equipment, and brigade organization and provide for efficient coordinated action in the event of fire.

5. Direct all operations in drills and in event of fire have complete authority and command over all fire-fighting operations and all plant employees and operations pending arrival of public fire department officers, after which time he should advise and assist those officers.

6. Assist as required in rescue work.

Automatic Sprinkler Equipment

The Plant Fire Chief should understand that this most efficient form of industrial plant fire protection, to be effective, must be complete in its coverage and be in service at the instant fire occurs, with devices operative, water supplies normal, and controlling valves wide open.

He should make all necessary provisions to:

1. See that sprinkler protection is provided before occupancy of any new buildings or areas requiring such protection.

2. Prevent any unnecessary interruption of sprinkler protection by valve closure, withdrawal of water supply, or other circumstance.

3. Prevent any tampering or interference with the sprinkler equipment, its water supples or controlling valves.

4. Reduce to the shortest possible time and extent any necessary interruption of the sprinkler protection and during interruption provide emergency measures for protection, such as special watch service, emergency water lines to sprinkler equipment, hose lines, special first aid equipment, and special notice to fire brigades and public fire department.

5. Make sure that in event of fire or explosion, or bombing raid, the sprinkler equipment is kept continuously in service with all water supplies until it is certain that all fire is out or that the piping system is disabled or damaged beyond usefulness.

6. Know at all times the condition of the equipment and its controlling valves and supplies.

7. Ensure that no building is left unattended after a fire until the sprinkler protection is restored.

8. Make sure that sprinkler equipment and other fire-fighting appliances are properly arranged for winter service and are not impaired by freezing or obstructed by snow or ice.

NOTE: Modern automatic sprinkler protection rarely fails to extinguish or effectively control fire. Automatic sprinklers have also proved to be very effective in extinguishing incendiary bombs. When failure does occur, the failure usually can be traced to one or another of the following causes:

Control valve closed, due to carelessness, tampering, or necessity.

Control valve closed too soon, before fire was out or by error.

Obstruction in the sprinkler piping.

Pump crippled or tank empty.

Water lines or dry-pipe valve frozen.

Heavy losses have resulted from watchmen, firemen, or others shutting off sprinkler equipment, thinking there was no fire, that fire was out or under control, or seeking to prevent water damage. The Fire Chief of a sprinklered plant has no more important duty than to make sure that such mistakes will not be made in his plant.

After a fire, he should make certain that all the sprinkler heads which have operated are promptly replaced and protection restored. He should see that a man remains at the control valve during every shut-off.

AIR RAID WARDEN SERVICES

The Air Raid Warden Services may be set up under the Fire Chief, the Chief of Police or as an independent group. In any case, there will be a Chief Air Raid Warden. The number of Deputy Wardens will depend upon the size of the plant.

Wardens are responsible for reporting damage to the Plant or Division Control Room, for blackout measures, for directing employees to shelter areas, and for providing the leadership that will help to maintain morale. Individual Wardens may be detailed as plane spotters, fire watchers, messengers, floor and stairway attendants.

Because of their responsibilities, Wardens should be chosen with particular care for their qualities of calmness, leadership, and judgment. They must be level-headed and resourceful and have the ability to inspire confidence.

The plant Air Raid Warden must know how to handle people when they are under great strain; he must be a sort of combined Police Officer and big brother to his fellow employees. He may be assigned specific responsibilities, such as throwing nearby light or operating switches, obscuring nearby windows, leading personnel to shelter areas, and similar duties.

The number of Wardens required in proportion to the total number of workers depends on many variable factors, such as the type of protection required, size of plant, number of employees, class of building, etc. In some cases, the Wardens may be very few and greatest emphasis will be given to fire protection services. In others, where transfer of personnel might be difficult or slow, there should be a larger number of wardens.

Duties of Air Raid Wardens

Plant Wardens should be assigned to definite floor areas with the responsibility for specific personnel groups.

Wardens must be familiar with all local warning and communication systems, and must be prepared to carry out their duties immediately upon the receipt of the indicated signal or order.

Wardens must know where and how to report damage. They must know the complete details of blackout measures in the areas to which they are assigned.

Wardens should also be prepared to function as messengers should regular communications fail.

Special units of Wardens, known as searchers, may be organized to go through certain areas of the plant, such as storerooms, washrooms, restaurants, offices, locker rooms, etc., to make sure that all persons are accounted for before, during, and after raids.

Wardens should have knowledge of first aid, although this is not their primary function, and must be familiar with the various war gases so that they can be reported.

Observers and Fire Watchers

Fire Watchers are organized under and trained by the Chief Air Raid Warden. Their posts are selected by the Plant Fire Chief, in coordination with him.

Their function is to watch all roofs, to report the fall of bombs on or in the plant, and to deal with such incendiary bombs as fall near them.

This requires a sufficient number of posts, so placed that, between them, all roofs and areas in the plant are observed. The number will depend on the layout and size of the plant. Each post must be given a means of communication with the plant Control Center.

If it is desired additional observers may be placed on points of vantage at the time of an air raid, to observe progress of control measures.

Bombing planes drop thousands of incendiary bombs. There should be an active group of trained men continuously on watch during periods when there is any danger of attack. This watching should ordinarily be done by groups of three or four men, with enough such groups for any one building or area to take care immediately of all the incendiary bombs likely to fall. This may require a large total protection force in addition to the normal plant fire brigade.

NOTE: Special training is necessary for the handling and control of incendiary bombs. See Appendix II.

Local Protection—Control and Transfer of Personnel

Experience has proven that bomb casualties to people in open areas are much greater than to people under cover and that personnel in a plant are safer in the plant than if they leave it. Therefore, general evacuation of the plant usually should be avoided. That part of the plant which is considered to be safest from the blast or fragmentation effect of a bomb should be designated as the air-raid shelter and plans should be made for the orderly transfer of employees to that "Safety" area. If there are no "safe" places in the plant, it may be possible to arrange for the transfer of personnel to some multi-storied fire-resistive building in the immediate vicinity. Concentration of too many people in one area should be avoided unless they are separated by protective walls that will withstand the blast effect of a bomb.

At the "alert" warning, the men designated for defense positions should take their stations, but the transfer of personnel should not be ordered until the plant's own air raid signal is given.

The safest areas are locations with at least two or three floors overhead and at least one floor beneath, protected by inner walls from the effects of flying glass. After selecting the relatively safe areas, the means of transfer should be considered. Direct routes to shelter areas should be marked out with emergency pilot lights or luminous signs, and Floor Wardens, Stairway Wardens, and Shelter Wardens should be designated and instructed in handling the transfer of personnel, so that hysteria and confusion may be prevented. Lights designed to remain lit during blackout, such as aisle safety lights, obstruction lights, and shelter lights, should be installed. First Aid Crews should be trained.

It is important that personnel be instructed in the precautions to be taken before going to the "safe" area. Such precautions include shutting off of motors, stopping of machines, placing of blueprints, records, vital instruments, and secret papers in safe places, protection of dies and tools, and taking every possible step to prevent damage, waste, and accidents.

As saboteurs may prefer to work in the dark, it is necessary that Floor Wardens be instructed to guard against the starting of fires, damage to machines, or other acts of sabotage during blackouts.

Shut-Down of Processes

In cooperation with the Operations and Maintenance Department, Wardens should ascertain by personal check that individual machines, processes, etc. have been shut down according to the prearranged plan.

POLICE SERVICES

Police Services are responsible for the maintenance of discipline and for the general safeguarding of personnel, property, and operations, excepting those measures which are specifically assigned to other divisions. They are also charged with the prevention of subversive activities and sabotage. Some of the possible general methods of sabotage that should be guarded against during air raids or air raid drills are the following:

Damage to vital machines, precision tools, or equipment by breakage, chemicals, or infernal machines.
Damage to power stations or parts of utility systems.
Damage to raw materials in process or finished products.
Damage to or theft of blueprints, formulae, or other confidential data.

A Police Chief should be appointed to head this division. He should be responsible for the organization and functioning of all Police, Guards and Watchmen. In many plants where Police Services already exist, they should be expanded to meet emergency conditions.

Police Duties

Police duties and responsibilities include:

Guarding gatehouses or plant entrances, for the purpose of passing only properly identified employees in and out and for the registering and checking of legitimate visitors.
Patrolling all areas inside and outside buildings on the plant premises.
Guarding against malicious damage to vital power and utility facilities, machines, equipment, supplies of strategic material, and other valuable property.
Safeguarding vital records, specifications, instruments, valuable material, explosives, or toxic substances, etc.
Enforcing all properly established rules, stopping and reporting all suspicious persons, reporting fire hazards and anything noted that may affect the safety of the plant.

Immediately after a raid, police should make special patrols to check additional precautions to be carried out before certain areas in the plant are re-entered by employees for resumption of regular operations. Re-entry should not be permitted until Police Patrols have reported that re-entry may be made safely.

Police should see that tool cribs, stock rooms, and supply departments are locked and made safe.

Police should supervise locker rooms, where great confusion may occur as a result of employees trying to get personal belongings.

Police may assist in carrying out blackout plans and in enforcing the wearing of gas masks when necessary.

Watchmen

The Police Chief should:

See that the watchmen are physically and mentally qualified for their work, loyal, properly instructed, and properly supported and supervised.

Instruct and train Watchmen in their Police and Patrol duties and provide them with proper equipment.

See that each watchman knows when, where, and how to give an alarm, especially how to operate the public or private fire alarm box, whom to call on the telephone, and how the call is to be made.

See that watchmen's routes and hours of coverage are correlated not only to points and times of special hazard of fire, but to dangers of trespass and, if necessary, varied as to time in route so as to give proper protection.

See that watchmen know how to communicate with the Plant Control Room during an air raid.

Internal Traffic Control

Police should control all internal traffic and maintain clear routes to permit the necessary air-raid units and equipment to reach the scenes of accidents. Before, after, and during blackouts, they should assist in carrying out all evacuation plans. Among other places, they should be stationed at exits, entrances, elevator doors, stairways, and escalators.

Discipline

During raids, the maintenance of discipline and morale as well as the control of hysteria and panic is a major responsibility of the Police Services. Hysteria and panic during an air raid may result in a high number of casualties even if actual bombing causes little, if any, damage to buildings.

Unless police are distinctively uniformed, it is most important that they be supplied with prominent insignia to indicate that they are key men or leaders in time of emergencies. Arm bands are usually satisfactory or cloth caps of the overseas type may be supplied. The very sight of uniforms or such insignia being worn by these key people in an emergency will inspire confidence.

In buildings where members of the public may come in off the streets to seek shelter during a raid, police should be especially assigned to this problem and be prepared to instruct and supervise such people. They should explain:

What the warning means.
That a plan exists for everyone's protection.
That people must keep calm.
That the building they are in is in itself a shelter.
That people must cooperate and do as they are told, such as moving in an orderly manner to a designated area.

Vehicular Traffic Within Plant Premises

Major objectives regarding plant vehicular traffic and parking are (1) to keep the roadways and vehicle entrances and exits open to permit movement of emergency equipment and vehicles; (2) to provide maximum possible protection to motor vehicle occupants entering or leaving plant; (3) to prevent vehicles from being parked where they constitute an additional fire risk; and (4) to provide maximum protection to parked vehicles.

To achieve these objectives, control of all plant vehicular traffic should be placed under the plant Police Chief, who should issue the necessary instructions.

Insofar as possible, the plant should prepare its traffic rules for blackouts and air raids to conform with the general rules established for local traffic operating on the public thoroughfares.

Vehicle operators leaving plant parking lots when blackouts or air raids occur should be instructed to:

> Pull to curb if on plant property, or move into nearest vacant parking stall if just leaving parking lot, in order to keep roadway and parking lot aisles open for the movement of emergency equipment. Turn off motor and lights, set brake, and leave doors unlocked. Seek cover in nearest designated building.

Bulletins and posters should be issued and posted informing motor vehicle operators of the plant rules for operating motor vehicles during a blackout or air raid.

Plant roadways and parking areas should be policed during blackouts and air raids to make sure motorists conform to rules. Precautions should be taken to prevent the seizure of cars by saboteurs, parachute troops, etc., at the same time considering the advantage of being able to quickly move the cars if necessary.

Unexploded Missiles

The Police should be charged with the responsibility of taking certain immediate precautions for unexploded missiles, such as:

Consider the protection of life first and clear the surrounding areas of all personnel.
Rope off areas around unexploded bombs.
In cooperation with the Operations and Maintenance Chief and Fire Chief:

1. Remove combustible materials from the immediate vicinity to prevent their ignition in the event the bomb explodes.
2. Have Operations department disconnect power lines in the immediate vicinity and shut off gas, if advisable.

"UXB" Disposal

The disposal of unexploded bombs ("UXB") is a function of the Army. When an unexploded bomb is found, safety precautions (as above) must be taken and a prompt report made to the Plant Control Room, which should notify the local Control Center, from which point a Bomb Reconnaissance Agent will be dispatched to the plant. Larger plants might consider the advisability of appointing a Plant Bomb Reconnaissance Agent who would be trained in accordance with the standards required of such agents.

The Bomb Reconnaissance Agent will establish the category (priority for removal) of the bomb; the action thereafter will be by the local Control Center and the U. S. Army.

MEDICAL SERVICES

The increasing demand placed upon industry by the war effort has tended to bring about longer working hours and poor housing and sanitary conditions which increase the tendency to fatigue. Semi-skilled and unskilled labor has been employed to perform tasks normally given to skilled workers. New chemicals and new methods of manufacture have been introduced. All these factors have increased the problem of the industrial hygienist.

Man power must be conserved. Absenteeism due to illness and industrial accidents must therefore be reduced to the minimum. To this end every plant, large or small, should establish an adequate industrial medical service, if it has not already done so. Assistance may be secured in the establishment of such an organization by application to the Industrial Hygiene section of the State Department of Health, the Industrial Hygiene Division of the U. S. Public Health Service or the Council on Industrial Health of the American Medical Association.

If the plant has a well planned and adequately staffed Industrial Hygiene Department, the problem of organizing an Emergency Medical Service to cope with problems brought about by bombing or other forms of direct enemy action will be simplified. The Emergency Medical Service will merely be an expansion of the program already instituted.

All industrial plants are expected to provide medical services and First Aid equipment within the plant for the care of the injured. In the event of enemy action directed against such industrial plants, the physicians, nurses, and first aid detachments within the plants may be inadequate to care for the serious injuries produced by high explosives or incendiaries. It is recommended that each industrial plant, in addition to providing its own medical staff and first aid equipment should plan in collaboration with the Chief of

Emergency Medical Services of the locality for:

(1) Services of ambulances and Emergency Medical Field Units when needed;

(2) Available beds at one or more hospitals to which the severe casualties may be transported;

(3) The establishment of a Casualty Station of the Emergency Medical Service within a short distance of the plant;

(4) Obtaining the services of Emergency Medical Field Units if needed to supplement the plant medical service during an emergency.

If a plant is miles from a hospital and there is, therefore, a possibility that the injured might be obliged to remain at the Casualty Station for many hours before being transferred to the hospital, the Casualty Station should be larger than the average for a given number of employees and be adequately equipped. It must have cots, blankets, water, heating facilities, and be equipped at least with the emergency medical supplies outlined in Medical Division Bulletin No. 2, equipment lists 1 and 2.

As the Casualty Station will be established by the local Chief of Emergency Medical Service to serve the employees, the plant should consider bearing the cost of the equipment.

In addition to the Casualty Station which may be established adjacent to the plant by the Emergency Medical Service, similar but smaller stations should be organized within the plant. The plant hospital or dispensary is usually best suited for this purpose, but other stations should also be established in various wings of the plant. The Plant Casualty Stations should have direct telephone communication with the Plant Control Room. Plant medical personnel should be organized by the Medical Director into teams consisting of a physician, one or more nurses and assistants. These teams should be available not only to operate the Casualty Stations but also, when necessary, to advance close to the scene of the incident where temporary first aid posts may be established.

The primary function of the Casualty Station is to care for the slightly injured who do not need hospitalization and thus protect the hospitals of the community from the burden of caring for minor casualties. In addition, it will serve as a center for the dispatch of the various medical services to different parts of the plant, and for the storage of medical supplies, such as stretchers, blankets, and bandages. Such locations may also be used as points of assembly for rescue units, stretcher teams, first aid workers, and other medical auxiliaries.

First aid posts are established at the time of emergency as near as possible to the site where casualties are being extricated. The medical units at such advanced posts—

(1) Ascertain the number, position, and nature of the casualties in order to determine the extent of the medical problem and the priority of treatment and removal;

(2) Provide life-saving emergency medical care;

(3) Determine, as far as possible, who needs hospital treatment and who can be cared for at a Casualty Station;

(4) Secure ambulance transportation and other assistance required from the local Emergency Medical Service;

(5) Assist in the loading of ambulances;

(6) Endeavor to maintain morale in the area.

Hospitals.—All general hospitals in the community, voluntary as well as governmental, are included in the Emergency Medical Service. The community Control Center will designate the hospital to which casualties from the industrial plant may be sent and, through the Chief of Emergency Medical Service, it will provide Emergency Medical Units, Stretcher Teams, and ambulances.

Stretcher Teams.—Teams of trained stretcher bearers should be organized among the employees by the Medical Director as part of the medical service. The stretcher team is composed of four individuals, one of whom is the leader, who have been trained in first aid procedures and have received supplemental training and drilling in extricating injured persons from difficult positions, in loading and carrying a stretcher, and in loading and unloading ambulances. It is desirable to train five percent of the plant personnel in these duties in order to have stretcher teams on call during each shift and in each wing of the plant.

The following is the minimum number of stretchers recommended:

For 1–99 employees—1 stretcher for each 25 persons
100–499 employees—1 stretcher for each 50 persons. (Minimum of 4)
500 or more employees—1 stretcher for each 100 persons. (Minimum of 10)

Similar groups of employees should also be trained and drilled as rescue units for light demolition work and in the extrication of victims caught in demolished buildings.

Ambulance Service.—The majority of the plants will depend largely on the surrounding communities for ambulance service. However, it will be advisable for plants to provide improvised ambulances for their own use in the event of an emergency. All requests for ambulance service from the community should be made to the Control Center of the Citizens' Defense Corps.

Reference is made to the "Handbook on Transportation of the Wounded" (in preparation) and "Handbook of First Aid" published by the Medical Division for a discussion of the improvisation of ambulances from trucks, station wagons, etc.

OPERATIONS AND MAINTENANCE SERVICES

Protection of the buildings, equipment, and supplies that tend to maintain production should be under the Operations and Maintenance Chief, who should be a competent all-round engineer, qualified to act in all emergencies. He should have as his assistants the mechanics who deal with plant utilities such as electricity, steam, gas, and water. Skilled workers, such as plumbers, pipefitters, machinists, electricians, welders, etc., should be detailed to key positions, ready to do whatever is necessary.

Plant Lay-outs

Diagrams showing the location of all important valves, piping, and electrical circuits with their control switches should be drawn up (under direction of the Defense Coordinator) and all persons who may be called upon to operate such equipment should be familiarized with their location. Such diagrams should be kept in locations of relative safety, so that they will be immediately available in the case of emergency. Important valves and switches should be clearly identified, so that no errors or delays will be encountered when the operation is attempted under emergency conditions.

Fuel Gas

Plants that use fuel gas should be equipped with shut-off valves. One person for each shift, plus an alternate, should be made responsible for closing such shut-off valves, if necessary. These persons should also be responsible for seeing that, after the emergency has passed, control valves and pilot valves on gas-consuming apparatus are closed before shut-off valves are opened, pilot lights are properly lighted, and other gas-consuming apparatus is lighted in a manner that will prevent an explosion of unconsumed gas. Any gas-fired equipment should not again be put in use after extinguishment until thoroughly vented. The local gas company should be consulted on questions of procedure.

Boilers

Boiler plants of all kinds equipped with full automatic controls are preferable in meeting emergency conditions, provided such controls are well-maintained. When automatic controls are not available, the boiler-room staff should be instructed to carry out the following in the event that production has to be interrupted:

Hand fires should be burned as low as possible to maintain steam. Steam pressure may be carried at about 10 lbs. below the safety-valve setting to prevent safety valves from blowing in case the load is suddenly cut off.

A relatively low water level should be carried.

Auxiliary feed pumps or injectors should be prepared for immediate use. Where both steam and electrically-driven pumps and auxiliaries are available, steam units should be started. Steam-operated fire pumps should always be ready for immediate service.

Gas, oil, or pulverized fuel burners should be shut off or hand fires drawn of all boilers not required for maintaining steam to operate fire pumps or electrical generators providing current to such pumps or other vital services.

Wherever possible, any feeder or supply line, pipe, conduit, or system should be shut off as near to the original source of supply as possible to minimize the exposure resulting from the extended system throughout the plant. If steam-heated vessels or ovens are being used, the steam should be shut off at the boiler-room end of the line and the lines should be drained before live steam is again admitted.

Water supply lines, where they are essential or helpful to the fire-fighting equipment, should never be turned off. Circumstances will govern the application of this rule.

On all boilers not required for important services, steam pressure should be dropped to about one-half of the original pressure, and main stop-valves should be closed.

Boilers fired with gas, oil, or pulverized fuel should be cooled by opening draft doors and shutting down forced-draft fans. Care should be taken that normal safe shut-down procedure is followed even in emergencies.

Be sure to arrange for at least one boiler in service if there is a steam fire pump on the premises.

Induced-draft fans must be kept in operation until all gases or unburned fuel have been removed from the settings. When this is accomplished, induced-draft fans should be shut down.

Suction lines and oil heaters of oil-fired boilers should be drained when possible.

Piping systems for any flammable, explosive, or poisonous liquids or gases should be shut down or so manipulated as to minimize the quantity discharged in case of rupture of piping, usually by closing valves at the source of supply.

However, valves should not be closed in cases where this might create an explosion hazard. In no case should valves be closed to isolate a section of piping without provision for emergency pressure relief. Great care should be taken to prevent inadvertent closing of valves on fire-extinguishing systems. Each individual process should receive careful advance study and a pre-arranged plan, understood by all employees concerned, should be made for the proper handling of each item of equipment.

After "All Clear"

The foregoing is in preparation to meet extreme emergency conditions, under which continued operations are impossible. When such conditions have ceased to exist and, in any event, just as soon as possible to restore operations after the emergency has passed, the boiler-room staff should act in accordance with the following instructions:

Carefully blow down boilers to the proper operating level.

Ventilate settings thoroughly to remove all unburned gases or fuel before lighting up.

If header valves have been closed, prepare to open in accordance with operating conditions (hand-operated valves) after headers and other lines have been bled.

Light off fires and raise steam in accordance with load conditions.

The foregoing anticipates resumption of operations in plants that have suffered no physical damage. If damage has occurred, a complete examination of boilers, piping, and auxiliary equipment must be made before attempting operation.

Prime Movers

Prime movers of all kinds must be kept in operation at all costs to prevent interruption of production, unless emergency conditions develop that make operation impossible. Operators should stand by their machines. When the signal that the load is to be removed is received, shut-down should follow in accordance with the usual operating instructions for the plant as the load is removed. Quick-closing valves, governors, emergency stops, independent speed-limit devices (and other control and protective devices) should be tested and inspected frequently so that their effectiveness in case of loss of load or other contingency is assured.

It is of prime importance in refrigerating plants that effective gas masks be provided in a special cabinet located outside of the rooms that may be filled with refrigerating gas in case of a system break. This cabinet should also contain a vapor-proof flashlight and a diagram of the system.

When the system is operated for the cooling of food or in connection with the production of munitions, it must be kept in operation. When emergency conditions develop that make shut-down imperative, the compressor should be stopped in the usual manner. With ammonia equipment, an adequate supply of water should be provided as a precaution against a system break. The free use of water in rooms where such a break occurs will partially absorb the ammonia gas.

Refrigerating systems should be equipped with adequate protective devices and automatic controls that will make the occupancy of compressor rooms unnecessary in the case of emergency.

All persons should be warned not to de-energize motor and control equipment or circuits unless they receive proper instructions, except in the case of an emergency of sufficient gravity to justify discontinuing production. Circuits serving fire pumps must be kept energized and an electrician should stand by at switchboards controlling the current.

Machine operators should be instructed that, in the event production becomes impossible, motors should be shut down by operating the individual motor controls. Only in extreme emergency should groups of motors be shut down by pulling the main switch, in which event the person charged with the responsibility of such a shut-down must also be responsible for making sure that all motor controls are in the neutral position before energizing motor circuits.

Ventilation

The means used for blacking out a plant must not greatly interfere with essential ventilation.

To ensure proper use of ventilating and heating appliances, supervision and daily check-up should be allocated to an experienced and responsible person.

Wherever a process that will continue to generate harmful smoke, fumes, gases, or dust must be left undisturbed during an air raid, it will have to be supplied with artificial ventilation facilities, and the necessary power for this will have to be supplied by special power wiring or other means. More than minimum safe standards of ventilation should be maintained.

Air-circulating or exhaust fans should be shut off unless such action will permit accumulation of dangerous or flammable vapors, fumes, or dusts in certain rooms. Fans used only for comfort should be shut off.

In rooms, dryers, and ovens where explosive atmospheres may exist because ventilating machinery has been shut down or dangerous fumes have been released by fire or other causes, dangerous fumes must be removed before operations are again resumed or before open flames, sparks, or ignition sources of any kind are created. There should be a rule that no valve shall be opened on return to work until the entire system has been checked to make certain there will be no explosion from the escape of gas or oil when it is turned on.

Special or Key Materials and Processes

When handling, storing or processing combinations of chemicals that are safe when manipulated under proper control, but which if uncontrolled may glow, ignite, explode, or react chemically in a dangerous manner, plans will have to be made in advance for stopping, suspending, destroying, neutralizing, or otherwise controlling the possible hazard. It may be necessary to dump, drown, or destroy the entire load or batch in process to protect against the possibilities of a direct bomb hit or the effects of flying particles upon such processes.

Special attention must be given to storage of flammable liquids, such as gasoline, solvents, and fuel oil. Suitable dikes should be installed around tank installations in yard areas. Flammable liquids should be stored outside main buildings. If inside storage cannot be avoided, it should be where tanks or containers can be easily drained if broken. A special drain-pipe to an outside pump should be provided.

In general, it is the processes involving the use of heat, or those which cannot be halted without a great deal of additional hazard as well as tremendous economic loss except perhaps at a few specific points in the process, that cannot be left unattended. They will be found in chemical, leather-tanning, rubber-processing and food-processing industries, bakeries, distilleries, breweries, refineries, glass and paper factories and many others.

Certain employees must, therefore, remain at their workplaces during the air raid. These employees should be warned of the danger and trained in methods of self-protection insofar as they can be protected at such times.

Those who must remain on duty must be well trained at fire extinguishment and, in general, know thoroughly the exact procedures necessary to meet any contingency in their departments.

Wherever the heat source in a process can be interrupted for a short time without damage to product, this should be done to minimize fire hazard. Examples are gas-fired kilns of clay products, pottery, or ceramics. Steam-heated vats, large tanks, or dry-kilns can be kept operating satisfactorily if the heat source is shut off temporarily.

Any device arranged for automatic feeding of fuel, blank stock or mechanical charging or ejection must be considered. In most cases it should be satisfactory for emergency shut-downs to be made by the employees who perform these operations regularly in each day's normal operations.

Maintenance men, repair men, millwrights, electricians, and plumbers will, in many cases, be found to be best acquainted with the processes of the plant as a whole and the methods of control of the plant's power, water, gas, and other utilities. After the Master Plan has been worked out for the entire plant, it will be necessary to assign individuals to each service point for each shift, and in most cases at least two persons should be acquainted with the duties to be performed at each emergency service point.

All small tempering furnaces, solder pots, electric heating-elements or irons should be turned off or disconnected. Gas burners should be turned off and pilot lights extinguished. Blow torches should be turned off. Gas-welding flames should be shut off and the welding gas or oxygen shut off at the cylinder valve. In plants equipped with a central gas generator or manifolded banks of gas cylinders, the gas should be shut off at the source. Acetylene generator rooms should have adequate ventilation by means of open windows, and, if the generator is of a type permitting shutdown at any time, the generation of gas should be stopped. Portable acetylene generators should be moved to the outside. Electric-welding generators should be stopped.

Heat sources under degreasing tanks, tempering pots, quenching tanks, acid and hot-water washing, pickling, or rinsing tanks should be shut off, unless a valuable charge of parts in process would thereby be ruined.

Steaming rooms or steam-heated dry-kilns or drying rooms may usually be left undisturbed, though the installation should be studied in each plant.

Machinery

Individual metal-working machines requiring no heat for the processing should be stopped by the operator if the control is located at the machine or by the control for the line or a group of machines. In most instances, this can be done with no loss or damage. Power should be disconnected from automatic machinery, such as air compressors and pumps for oil, solvents, and other liquids except water.

Woodworking Shop

Woodworking machinery should be shut off, usually either at the control for each machine or by a master control for the entire department or group of machines. Accumulations of sawdust or wood shavings should not be permitted. This reduces chances for spread of fire. In all departments in which the power is supplied to machines by means of an overhead drive shaft, the drive should be disconnected for each line of machines in addition to shutting down each machine separately. Responsibility for stopping conveyor lines or belts should be definitely assigned.

Tool Room

Like the maintenance men and millwrights, attendants in the tool room are usually well acquainted with the coordinated processes of the entire plant. Among employees of the tool room are likely to be found men capable of taking charge of important air raid service points.

The tool room must be left open and in charge of a dependable attendant, so that the stores of emergency or service keys, fuses, electric bulbs, flashlights, special safety equipment, ladders, ropes, plans of the building or grounds showing hydrants, sprinkler controls, etc. will be available.

The location and accessibility of keys to rooms or departments not often frequented should be checked. Duplicate keys should be procured and their location made known to several persons most likely to need them. This applies to elevator penthouses, outside storage buildings, garages, basement entrances, ignition keys for vehicles, keys for plant trucks, cranes, tool rooms, transformer rooms, kitchens, refrigerated rooms, gas generator rooms, etc. While the practice of locking many rooms or departments may be good for prevention of sabotage or thwarting marauders, it can also provide enough hindrance in times of emergency to cause tremendous loss by preventing access.

Milling or dry-grinding machinery should be shut off. The automatic feeding equipment to the grinder should be shut off. Accumulation of flammable or explosive dusts that might be ignited by shock, flame, or explosion must be prevented. Grain, starch, and other explosive dusts must be eliminated in open exposures wherever possible.

All spare parts and tools should be inventoried and listings of such spare equipment posted.

Every precaution must be taken at the time of emergency exit, so that conditions in the plant may not be more dangerous to life or property after returning than they were prior to the exit.

After Emergency Shut-Down

Any damaged portions of the building should be first entered only by trained men properly equipped with safety clothing to remove live wires, pull switches, restore light service, and examine the condition of the building to ensure safe working conditions.

CAUSES OF CASUALTIES

Casualties are caused principally by (*a*) glass splinters, (*b*) bomb fragments, (*c*) blast, or (*d*) other debris.

(*a*) *Glass splinters.*—All unprotected glass is a potential danger, as it is broken over a wide area by bomb explosions. In the case of direct hits and near-misses, splinters of glass are liable to be thrown with considerable violence.

(*b*) *Bomb fragments.*—When a bomb explodes, fragments of the case are thrown out at great speed and have a long range and powerful penetration. Protection is therefore most important.

(*c*) *Blast.*—Blast causes a violent disturbance of the air, but is less dangerous to personnel than are fragments. Injuries from blast are mainly the result of being thrown to the ground or against machinery or walls. Many cases of serious injury, due to such causes, have been reported.

(*d*) *Other debris.*—The bomb explosion may throw dangerous missiles, such as parts of the building, tools, etc., with sufficient violence to cause injury. There is also a danger of roof covering or other parts of the building dislodged by the explosion falling upon and causing injury to the personnel.

PROTECTIVE CONSTRUCTION

The effects of aerial bombings on buildings are dependent on various factors, including the type and size of the bomb, fuse setting, impact velocity and angle of impact of bomb, nearness of hit, and type of structure affected. Each individual building is a problem in itself. The framing, layout, and equipment contained and material stored therein must be studied.

In investigating the problem of direct hits, the possibility of a bomb striking a structure at any point on its exterior surface must be realized; thus consideration has to be given to lateral as well as vertical hits. Demolition bombs up to 1,000 pounds in weight have been known to penetrate from two to six floor slabs before detonating. No ordinary masonry or reinforced concrete wall can be counted on to deflect a bomb of medium weight. Thus, it may be said that the normal industrial building will suffer damage as a result of a direct hit, although such damage has been found by experience to be rather localized in character, except for possible removal of large areas of glazing or roofing.

The blast forces are set up by the compression and suction waves evolving from a detonated bomb. In interior building explosions, the blast effect can produce extensive damage if the blast is confined in small areas by walls. Steel and reinforced-concrete frame structures suffer considerable local damage but are resistant to collapse. Wall-bearing structures may suffer almost complete collapse because of interior explosions.

The blast effect from bombs bursting within close proximity to steel or reinforced-concrete frame structures produces localized damage to the outer portions nearest the detonation. Bombs bursting near wall-bearing structures cause extensive damage, even to the point of general collapse. For bombs up to 1,000 pounds in weight, the critical distance varies from 25 to 60 feet of the structure, being within the zones of expansion of the explosive gases.

As previously mentioned, detonation produces fragmentation of the bomb case. In interior explosions resulting from direct hits, the fragments may cause damage and loss of life beyond the critical blast-effect zone. Also, bomb fragments from near hits may pierce light exterior walls and windows and cause considerable damage and loss of life. Data on thicknesses of materials to protect from fragments of bombs of various weights detonating at a distance of 50 feet are given below.

Incendiary bombs now used vary from 2 pounds upward, the type most widely used weighing 2.2 pounds. These bombs will penetrate a light roof or wall sheathing. A 4 to 5-inch reinforced concrete roof is sufficient to prevent penetration of such an incendiary bomb. Experience has shown that the fire damage caused by incendiary bombs is extremely great, reports from abroad indicating that damage to steel in structures is ten times greater by fire than by explosives.

Thickness of various materials required for lateral protection against blast and splinters of a 500-pound demolition bomb at a distance of 50 feet[1]

Material	Required thickness
	Inches
Preferred:	
Reinforced concrete—3,000 pounds per square inch or better	12
Reinforced brick—cement or cement-lime mortar	13
Acceptable:	
Brick wall—cement or cement-lime mortar	13
Plain concrete	15
Sand or gravel between wood sheathing or corrugated iron	24
Sandbag wall	30

Protection

Based upon the foregoing data, it may be said that no place is safe against a direct hit of a heavy bomb. Certain precautions may be taken, however, to minimize the destructive effects of demolition and incendiary bombs. Industrial plants may be divided into four categories: (*a*) Steel-frame single-story shed buildings, (*b*) multi-story steel or reinforced-concrete frame buildings, (*c*) multi-story wall-bearing buildings, (*d*) other single-story buildings. Possible methods of dealing with the problem of providing protection for structures in these categories are given herewith.

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[1] Recent tests indicate that the above thickness will withstand perforation of splinters at 25 feet except in rare cases.

(*a*) Steel-frame single-story shed building structure should be designed as continuous frames, to permit collapse of one or more supporting members without collapse of the entire structure. In this type of structure a direct hit of a demolition bomb can penetrate the roof or exterior walls and cause damage to both. Where the interior of the building has large open areas, the erection of 12-inch reinforced-concrete or brick masonry walls 4 feet high, or as high as the parts of vital machinery to be protected, but not to interfere with production, would tend to localize damage and afford protection for both personnel and machinery. Such walls should divide floor space into areas as small as practicable and should *not* be tied into building walls. Where the exterior walls are constructed of light sheathing, the use of protective walls (see preceding table) around the outside perimeter of the building would increase protection against blast and fragmentation from near hits. Plants with glazed roofs present unusually dangerous hazards to personnel because of flying fragments resulting from direct and near hits. The hanging of a one-half inch wire-mesh netting directly beneath or inside the glazing would decrease this hazard. Asbestos-cement board may be used on walls but not on roofs, as it shatters and cannot be reused; corrugated iron is *not* satisfactory on walls but very good on roofs, as it is easily repaired and placed back in position.

(*b*) Multi-story steel or reinforced-concrete frame buildings. This type of structure is the most resistant to bombing and the interior areas may be fairly safe. As outlined in (*a*), where there are large open floor areas the use of blast walls will minimize injury and destruction caused by direct hits. The sand-bagging or other recommended protection of the first-floor windows will afford increased protection against blast and fragments from near hits.

(*c*) Multi-story wall-bearing brick buildings. This type of structure is liable to possible total collapse because of direct or near hits of demolition bombs. Its resistance can be strengthened by the addition of column supports adequately tied in. As this type of structure is normally non-fire-resistant, flammable materials should not be stored on the top floor.

(*d*) Other single-story buildings. Single-story structures not of steel-frame construction may be considered in the category (*a*) above, although there is more danger of structural collapse. This type can be made more resistant to blast by making the structural connections more rigid, so as to provide continuity of structure in the event of collapse of one or more supporting members. The steps outlined for lateral blast and fragmentation protection are to be included here.

Utilities

Experience in England has clearly demonstrated the importance of protecting vital points in factories. Trivial damage may suspend production for long periods. The most vulnerable points are the utilities—water, gas, and electricity—and essential machinery. Attention should be paid to the duplication or rearrangement of services to ensure that complete stoppage is not caused by one bomb. Very careful inspection should be made after every raid to make certain that no damage, which is not readily visible, has occurred.

Vital plant machinery, such as electrical equipment, switchboards, transformers, etc., may be protected by walls (see preceding table) at least as high as the vulnerable part of the machinery. An overhead roof of ¼-inch steel plate, properly supported, will protect against light incendiary bombs.

Machines individually powered are much less vulnerable to bomb damage than machines powered by shafting, as the latter is easily displaced and misaligned.

Underground utilities suffer serious damage from earth shock and movement, which dislocates sections of pipe, caves in large-diameter brick sewers, or breaks individual sections between joints. Underground utilities in the immediate vicinity of a bomb crater are usually completely shattered. Cast-iron and steel water mains are often found with longitudinal splits in the pipe as well as transverse cracks. Cast-iron gas mains, are usually badly damaged.

Underground telephone and telegraph cables suffer probably the least from the effects of bombs, since the conductors can stand considerable displacement and bending without destruction.

Power and telephone cables carried on towers or poles suffer little damage unless supporting structures are destroyed, which has never occurred to date. Insulators are often destroyed. Electrical machinery and generating equipment are subject to damage by movement of foundations and from bomb splinters, which also cause oil transformers to burn or be destroyed. Electrical generating plants, transformers, switches, etc. should be safeguarded by protective walls.

PROTECTIVE CONCEALMENT

To deal intelligently with protective concealment, one must have a broad perspective and must study the problem on a large scale.

Planning is the most important step and this should be done only in conjunction with those skilled in this particular field.

"Toning down" or the use of paints is one of the easier methods. Consideration should be given to the color, tone, and texture. Proper paint, when intelligently applied, is of great assistance in cutting down the visibility of the plant.

The use or non-use of planting material is also of importance. Planting serves best when it is consolidated with the neighborhood planting and is used to alleviate the straightness of lines and regularity of shadows and is excellent as a covering.

Overhead screens and appendages designed to get rid of shapes, outlines, and shadows are structural phases of protective concealment to which thought should be given in the final phases.

The use of smokescreens is a matter now under development and about which more may be heard. Any plan for camouflage must harmonize with the general camouflage program of the Region and should be approved by the Regional Director of Civilian Defense before any work is done.

A full discussion of techniques and materials may be found in the pamphlet "Protective Concealment" issued by the Office of Civilian Defense.

BLACKOUT

All plants will be prepared to blackout when ordered by competent authority. If the plant so desires, the plans for a blackout may be based upon a temporary cessation of work, unless the plant is designated by the War or Navy Department as one that must continue production even during a blackout.

The objective in any blackout or illumination-control scheme is to control the illumination so as to prevent it, or any reflection of it, from being seen by the enemy from above. This is accomplished by:

(1) Extinguishing.

(2) Effective screening.

Next to a proper air raid protection organization, blackout is the most important passive protection measure to be taken at night. The method and means of accomplishing a blackout will vary with the different plants and buildings and their location; but, if the problem is studied in consultation with lighting experts and local defense councils, solution is possible.

Quickness of execution of a blackout is an essential feature of any plan.

Methods of blackout may be divided into:

(1) The extinguishment of all exterior lights, the reduction of outside lighting to acceptable low intensities or the shutting down of light-producing exterior and interior operations.

(2) The blacking-out or obscuring of all openings through which light may be reflected or seen from above. This includes reduction of intensity of interior lighting and the possible use of the low-radiation colors, white and orange.

(3) A combination of (1) and (2), namely, extinguishment of some lights while others are blacked out or obscured and interior blackout lamps used.

The method used will depend upon the particular plant and whether it is desirable or necessary to maintain continuous operation under blackout conditions.

In the selection of the method to be used, consideration should be given to the practicability of the solution, ease of blacking out (obscuring, controlling, or extinguishing of lights), ease of obtaining, and fire safety of, materials, cost and probable life of materials, need to maintain continuous operations, combining of blackout precautions with protection from glass, need of lights at certain vital points, such as switches, valves, shelter areas, safety aisles, stairways, fire-extinguishing equipment, etc., and the safeguarding of the plant.

It is a matter that must be studied from the viewpoint of the particular plant and requires thought and initiative. The important thing is that, in the event of an ordered blackout, no light shall be visible to the enemy from above.

Materials

In areas where more than one raid may take place, it is hardly worth while to replace broken glass with new. If glass is broken, window openings are closed with some form of screen that will continue in use under more than one blast effect. Such screens of various materials are described below. They may be used with an opened window, so as to preserve the glass in the latter as long as possible.

Weather-resisting screens, easily made and put into place, completely filling window openings, should yield to blast and fall out harmlessly, so they can easily be put back again, or so hung as to fall back into place themselves. Such a screen arrests flying glass before the screen is displaced. It thus serves as obscuration and, if desired, may be made gas-excluding. Such screens are placed on the room side of windows. They may be made of or covered with any inexpensive, flexible, light-

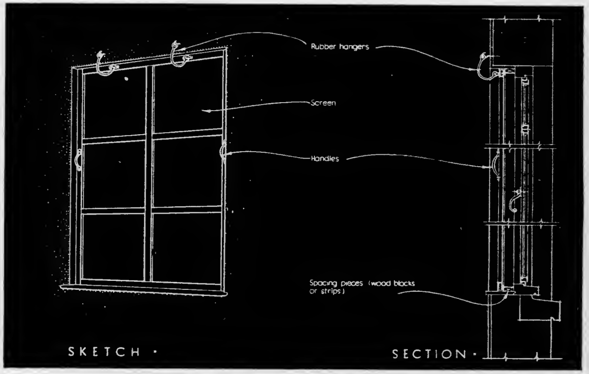


FIGURE 1.—Typical internal lightweight opaque screen.

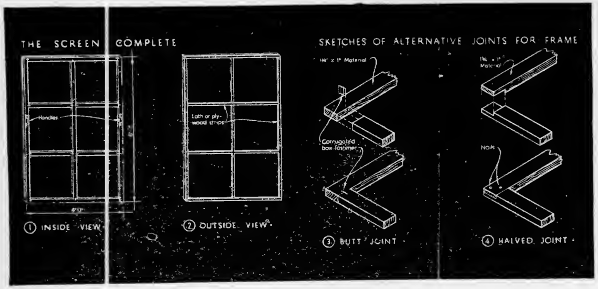


FIGURE 2.—Making lightweight screens (1) to (4) inc.

weight sheet material that is not likely to warp and can be made to resist rain. The sheet material should be mounted on a light wooden frame, unless rigid and strong enough to stand by itself. (See figs. 1 and 4.)

The following materials, not themselves waterproof, can be made reasonably rainproof with a single coat of oil paint. Varnish in a single coat is less effective. Edges of wood-fiber sheet materials are specially liable to soak in moisture and should be thickly painted.

(1) *Strong liner paper.*—Minimum thickness should be .016 in. Suitable for windows well protected against blast and driving rain.

(2) *Corrugated fiberboard (or double-faced corrugated board).*—Can be used without a frame on small windows, say 4 by 2 feet or less. Edges should be protected with paper stuck on before painting.

(3) *Thick solid cardboards.*—Either a strong container board or chip-board.

(4) *Wallboard or building board.*—Insulating board about ½-inch thick or densely pressed board about ⅛-inch thick; the latter is preferable. These can be used without frames on small windows.

(5) *Plywood.*—Any grade is suitable; 3-ply is usually adequate but liable to warp.

(6) *Wire netting and fabric.*—(Described elsewhere.)

(7) *Very thin box crate boards.*—Since these are available in small sizes only, cross battens or frames with cross members are necessary.

(8) *Bituminous sheeting.*—Any good roofing felt that offers good resistance to tearing. Should be well supported in frames by cross members. Linoleum may be similarly used.

Screen construction.—Screen materials should be framed according to kind, strength, and size of individual screen. Extra weight and strength are undesirable, a simple test being "if the frame can be carried in the hands without flapping or distortion, it is strong enough." A typical screen for a window 6 feet high by 4 feet wide can be framed with 1- by 2-inch wood. (See fig. 2.) If covered with wallboard, no cross members are needed, but if with liner board, bituminous sheeting, or other like material one or two cross members each way should be provided, partly to give strength and partly to provide extra framework for nailing the sheets. Corners usually require bracing.

Strong sheet materials can be nailed to the frame and nails clinched in back; liner board or corrugated fiber-board should be held between plywood strips or plaster laths and the frame, the whole securely nailed together. Alternatively, the sheet material should be bent around the edges of the frame and tacked at the back. Joints of frame members are most easily made with corrugated box fasteners simply hammered in. Alternatively, joints may be mortised and nailed and wood or metal angle braces or blocks may be used. (See fig. 2.)

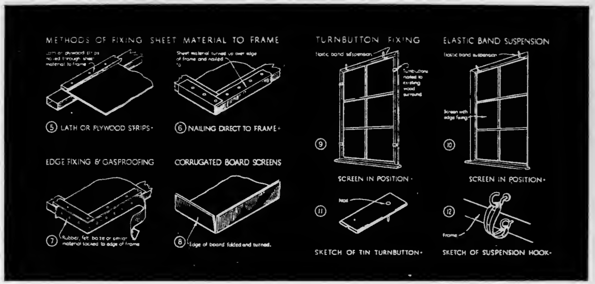

METHODS OF FIXING SHEET MATERIAL TO FRAME
Lath or plywood strips nailed through sheet material to frame
⑤ LATH OR PLYWOOD STRIPS
Sheet material turned up over edge of frame and nailed to
⑥ NAILING DIRECT TO FRAME
EDGE FIXING & GASPROOFING
Rubber, felt, baize or similar material tacked to edge of frame
⑦
CORRUGATED BOARD SCREENS
Edge of board folded and turned.
⑧
TURNBUTTON FIXING
Elastic band suspension
Turnbuttons nailed to existing wood surround
⑨
SCREEN IN POSITION
Nail
⑪
SKETCH OF TIN TURNBUTTON
ELASTIC BAND SUSPENSION
Elastic band suspension
Screen with edge fixing
⑩
SCREEN IN POSITION
Frame
⑫
SKETCH OF SUSPENSION HOOK

FIGURE 2.—Continued (5) to (12) inc.

A strip of felt, flannel, or other thick fabric, tacked on the outside edge and over the face of the frame to make a close fit with the window frame, is necessary where the screen is to keep out gas. (See fig. 2 (7).) It also allows a fairly tight jamming fit to hold the screen in place against moderate wind pressures, and in some cases no additional fixtures are necessary. (See fig. 2 (10).) Where some extra fastening is needed, it must not be so strong that the screen itself is broken when struck by blast but will readily fall away from the window harmlessly as a unit. Extra fastenings may be ball catches or turnbuttons (fig. 2 (9) and fig. 4), either standard or improvised.

Fitting screens to windows often presents minor difficulties. Almost all windows have three alternative positions for screens, which are:

(1) Close against the frame of the window.

(2) In the space ("reveal") between the window frame and the inside wall face. This is the most usual.

(3) On the inside wall face.

Each screen can, if necessary, be given a pair of handles for lifting it into place. Wooden blocks or fillets can be nailed in the space between the screen and the window, against which the screen can be pressed into place. Difficulties will often be presented by projecting window mouldings, casement window handles and rods, or blind and curtain fixtures. These may either be removed altogether or a hole cut in the screen to receive them, the hole being covered by loose cloth bags, the edges of which are stuck by an adhesive to the screen material. Alternatively, the screen may be placed on the inside wall-face in order to clear such objects.

Very large windows may require multiple screens; for example, a wide horizontal window may have two or more screen units side by side covering the window. Edges between screen units need an overlapping strip of wood, and adjacent screens may be held together by light wooden bars in slotted wood or metal brackets.

The units of multiple screens should not be much larger than 6 by 4 feet.

All but the lightest unframed screens should be suspended so that they do not fall to the floor when thrown out by blast. This is best done by fastening the screen frame to the window head or lintel with lengths of wide elastic or rings cut from old automobile inner tubes. The elastic material should be long enough to allow free backward movement of the screen, but not enough to allow it to strike the floor. The use of flexible loops allows the screen to be taken down (figs. 2, (10) and (12)). Rope, cord, leather straps, or webbing may be used but are not as suitable as elastic materials.

Skylights

These are a more serious problem than regular windows. Obscuration is more difficult, particularly where it is desired to admit light during daytime. Weather protection must be far more thorough, especially when located above any object or goods liable to damage by moisture. Broken glass may do more damage falling from an overhead skylight than from a window. The best treatment of skylights is to remove the glass altogether and cover the openings with galvanized corrugated sheet steel, protected metal sheeting, or bituminous sheeting on boarding, placed to discharge rainwater safely. This plan involves the continuous use of artificial light. Removal of large areas of glass and substitution of weather-tight alternative construction is often too costly or difficult, if not wholly impracticable. In such cases, as an alternative, external obscuration systems that resist weather may be provided, together with measures to reduce damage from falling glass. Several patented obscuration systems, applicable to long lengths of skylight, as in sawtooth roofs, have been devised; some of these allow units to be folded back during daylight, either mechanically or by hand. They should be designed to exclude wind and rain, whether or not the glass remains unbroken. Wire netting of one-half inch or smaller mesh, which may also be covered with fabric, firmly fixed below the glass and as near to it as possible, should arrest all but the smallest fragments of glass; an adhesive coating on the glass, in addition, reduces risk of small fragments penetrating the netting.

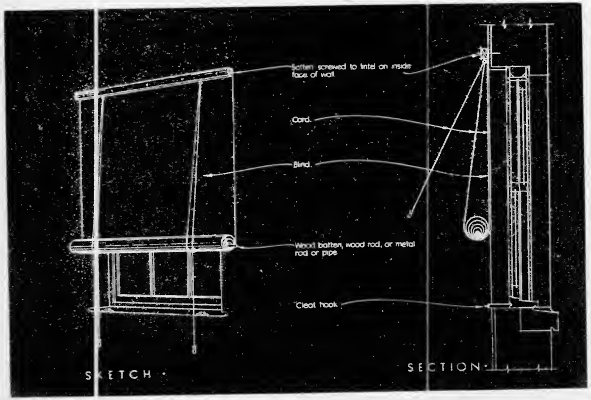

Batten screwed to lintel on inside face of wall.
Cord.
Blind.
Wood batten, wood rod, or metal rod or pipe
Cleat hook
SKETCH
SECTION

FIGURE 3.—Temporary improvised screen blind (window shade). (Material should be flame-proofed.)

Obscuration systems placed internally arrest falling glass but do not prevent rainwater dripping from the lower edges of the sheet materials. Covering glass with an all-over treatment, such as textile and adhesive together with wire netting below, should effectively prevent all broken glass from falling and, when the glass is broken, give some resistance to weather.

A preferred method of covering the glazed area for permanent blackout and anti-scatter treatment of glass is to cover the glass with either of two types of coatings, at least $\frac{1}{16}$-inch thick, and stick membrane fabric material in the coating. It should be made certain that the asphalt coating will be suitable for use in the various temperatures that may occur in areas where the plants are located. Experiments are now being conducted to determine the effectiveness of good "long" paints and synthetic resin "dopes" as anti-scatter treatments for glass.

1. *Application.*—The glass surfaces and the glazing bars, window sash, and/or frame should be cleaned to remove all dust, grease, and foreign matter. Do not apply the coating on wet or frosted surfaces. The coating may be either brushed or sprayed on the surfaces. Do not attempt to spray coating that contains any fiber unless suitable spraying equipment is used.

2. *First coating.*—The glass surface, glazing bars, window sash, and/or frame should be covered with a coat of fire-retardant asphalt coating on the basis of about 1 gallon per 100 to 150 square feet of surface. Coating should extend beyond the glass surface onto the sash not less than 4 inches, or the width of the frame member in the sash or the window frame if a membrane is to be used. This asphalt coating may conform to either of the following specifications:

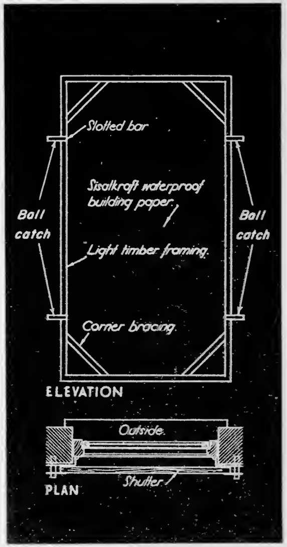


FIGURE 4.—Inexpensive form of lightweight screen.

Asphalt Solvent Coating Specification

Softening point, solid asphalt.—Minimum 160° F.

Recovered solvent.—Initial boiling point not less than 250° F. and a dry point of not over 450° F.

Slide test.—When the coating is applied $\frac{1}{16}$-inch thick on a panel of sheet metal or glass with a thread placed in the coating 1 inch from the bottom edge and parallel to the edge and the specimen hung vertically with the thread down and then cooled, there shall be no slippage downward of the thread.

Minimum asphalt content.—50 percent.

Maximum fiber or filler content.—Not over 19 percent.

Viscosity reducing agents and resin to prevent jellation.—Not over 5 percent.

Solvents.—Balance.

CAUTION: Keep open flames away from this material when applying and until dry.

Asphalt Colloidal Clay Emulsion Coating Specification

Softening point.—Not less than 105° F.

Flash point.—Minimum 500° F.

Asphalt content.—Minimum 47 percent.

Water content.—Minimum 48 percent.

Mineral colloid.—5 percent.

Asphalt colloidal clay emulsions.—After drying, shall produce a film or coating that is not soluble in water.

3. *Membrane.*—Lay the membrane into the first coat of asphalt while it is still tacky. This membrane is to be laid in one piece over the glazed surface, glazing bars, and window sash or frame, so that the lap on the sash or frame is at least 4 inches or the width of the sash or frame member. In this way, the membrane ties the glass more rigidly to the glazing bars, sash, or frame. The membrane should be firmly imbedded in the coating; lay loosely and do not stretch the material; press down all wrinkles. The membrane should be an open-weave cloth, such as tobacco cloth, heavy cheesecloth, etc. A suitable specification for the cloth is:

Approximate weight per square yard, 1.23 ounces.
Approximate thread count, 32 warp by 28 filling.
Approximate tensile strength, 18.8 pounds warp and 9.8 pounds filling.

4. *Second coating.*—If a membrane is used, it should be covered with another coat of asphalt coating over the entire surface of the cloth at the rate of about 100 to 125 square feet per gallon.

5. *Removal.*—An asphalt coating material can be removed later by means of a putty knife and kerosene as a solvent

6. *Condition of interior glazed surfaces.*—When asphalt coating is applied directly to the outside glazed surface, the inside surface is black. If it is desired to brighten the interior of the building to reflect more artificial lighting within, a "long" oil white paint may first be applied to the outside glazed surface and allowed to dry before applying the first coat of asphalt. Such practice permits the washing of the inside glazed surface to obtain better light-reflecting qualities; also, it is a little easier to remove the coating when it becomes necessary to do so.

Whitewash and the like can also be applied to the inside glazed surface if it is not felt necessary to apply it on the outer surface of the glass.

Blacking-Out Wire Glass Surfaces

A suitable treatment for wire glass that will eliminate the expense of the membrane and minimize splintering from the inside surfaces of the glass is to apply one coat of asphalt covering on both sides of the glass. The coat on the inside will minimize small glass splinters and the coat on the outside will eliminate the reflective surface of the glass.

A coating containing fibrous material is recommended to help the reduction of splintering effects.

Glass Coatings Without Membrane

It will perhaps be difficult to obtain enough membrane cloth to reinforce the glass against splintering.

If membrane material cannot be obtained, it is recommended that one coat of asphalt containing fibrous material be applied on the inside and outside of the window glass.

The application of asphalt on the inside surface will aid to some extent in preventing splintering and, of course, the asphalt coating on the outside of the glass will prevent the glass from reflecting light.

Skylights also may be broken by falling fragments of antiaircraft shell. None of the methods of treating glass described above will prevent damage from this cause, although some of them will save panes from falling wholly out when broken.

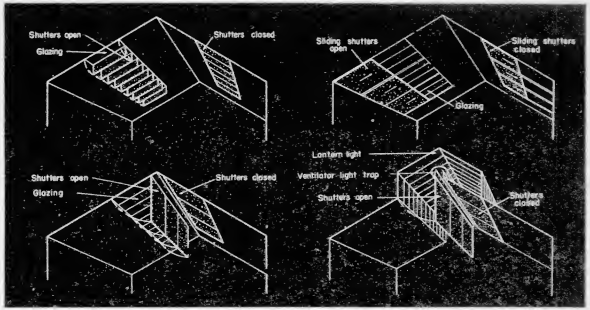


FIGURE 5.—Obscuration of skylights.

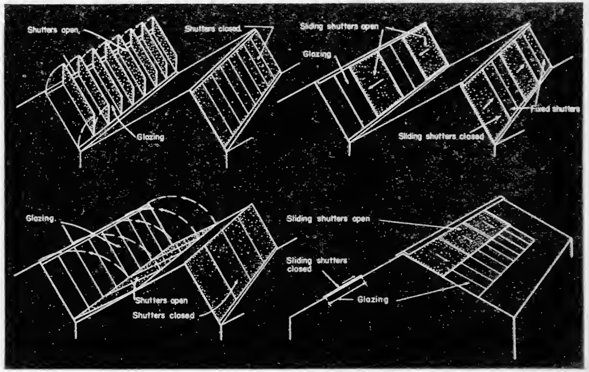


FIGURE 6.—Obscuration of skylights.

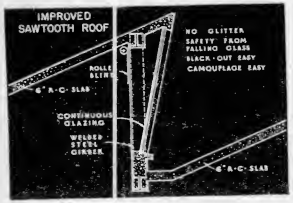
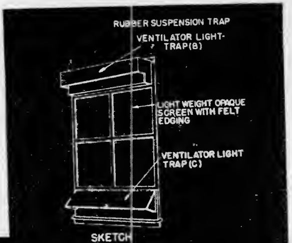


FIGURE 7.—Improved type of sawtooth roof construction.



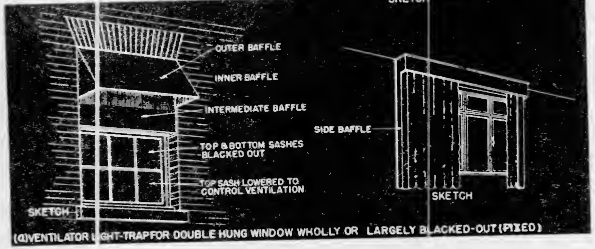

OUTER BAFFLE
INNER BAFFLE
INTERMEDIATE BAFFLE
TOP & BOTTOM SASHES BLACKED OUT
TOP SASH LOWERED TO CONTROL VENTILATION
SIDE BAFFLE
SKETCH
SKETCH
(4)VENTILATOR LIGHT-TRAP FOR DOUBLE HUNG WINDOW WHOLLY OR LARGELY BLACKED-OUT (FIXED)

FIGURE 8.—Types of ventilators.

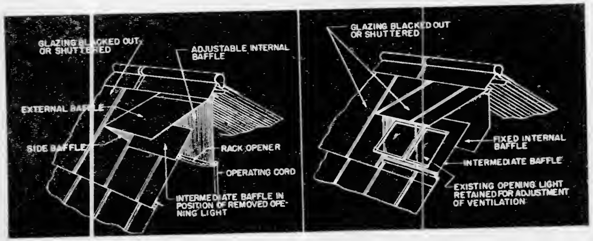

GLAZING BLACKED OUT OR SHUTTERED
ADJUSTABLE INTERNAL BAFFLE
EXTERNAL BAFFLE
SIDE BAFFLE
RACK OPENER
OPERATING CORD
INTERMEDIATE BAFFLE IN POSITION OF REMOVED OPENING LIGHT
GLAZING BLACKED OUT OR SHUTTERED
FIXED INTERNAL BAFFLE
INTERMEDIATE BAFFLE
EXISTING OPENING LIGHT RETAINED FOR ADJUSTMENT OF VENTILATION

FIGURE 9.—Types of ventilators.

Several general schemes for obscuration are shown in figures 5 and 6. An improved type of sawtooth roof construction, using wire glass (or glass backed by a wire screen) leaning outward at the top 10°–15° from the vertical in a 6-inch reinforced concrete slab roof, would answer most of these requirements in the case of new construction (fig. 7).

Typical Screen Installations

Figure 10 shows a sliding tray that enables skylights to be obscured in a few seconds and provides protection for the interior against flying splinters of glass broken by an explosion. The shutters slide on rods and are pulled to one side by means of a wire, which serves to open or close a considerable number of shutters in a single row, so that all of the glass in a large number of skylights may be obscured very quickly.

Where it is possible to gain access to the roof glazing conveniently from the outside, some such arrangement as shown on Figure 11 will be found the most convenient. Glass from every alternate bay in the roof glazing is removed and stored (but kept available for repairs during an emergency) and opaque painted boards of ¼-inch fiberboard are installed instead. By this means 50 percent of the light will be permanently blacked out. The obscured portions serve as storage space for the obscuring boards during daylight. To avoid the expense and difficulty of installing complicated hinge devices over the existing glazing bars, the arrangement shown (fig. 11) can well be adopted, as obscuring boards need be only 3/16-inch thick; such a board easily clips under the standard copper glazing clips at the base of the bar. Position of the obscuring board by day and by night is shown on the sketch.

Clipping an additional light steel tee section to glazing bars provides a similar method of wedge fixing of fiberboard covering for roof glazing and windows. It can be used on many types of glazing bars and fixed by unskilled labor. The slotted tee sections are permanently placed in position by means of special clips and left until it is necessary to obscure the light. When required, opaque boards can be fixed in a short time by means of wedges, which, being fixed without nails or screws,

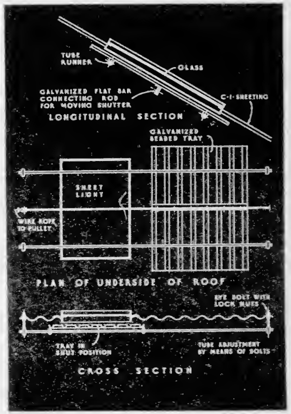


FIGURE 10.—Sliding tray screen under roof lights.

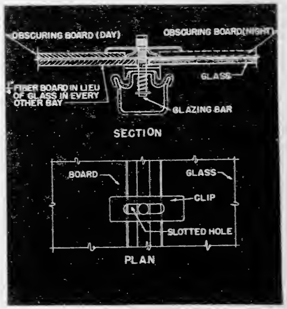


FIGURE 11.—External obscuring boards.

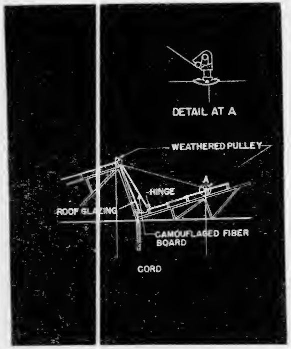


FIGURE 12.—External hinged shutters.

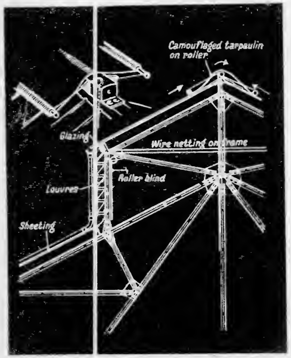


FIGURE 13.—Outside tarpaulin and inside roller blind.

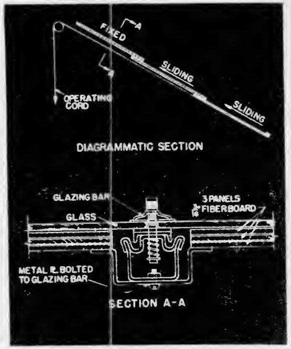


FIGURE 14.—Internal sliding shutter.

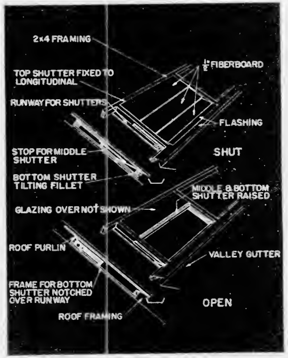


FIGURE 15.—Internal sliding shutter providing temporary weather protection.

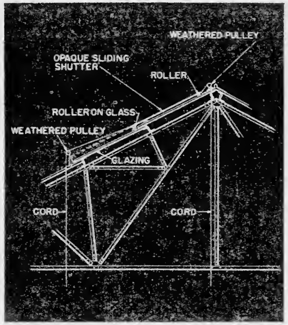


FIGURE 16.—External sliding shutters operated from the inside.

can be removed quickly and easily without damage. An adaptation of this method can be used externally or internally on vertical windows.

An arrangement for operating saw-tooth roof obscuration from the inside of the building is indicated on figure 12. Fiberboard shutters (which can be camouflaged) fixed to a hinge on one side of the valley gutter so as to lie on the sloping portion of the roof during the day are pulled over the roof glazing during the night, as indicated on the sketch.

Figure 13, with obscuration for monitor-type construction, shows a vertical roller blind over the inside of the louvers and a camouflaged tarpaulin on rollers operated from the ridge, generally as indicated over the top of the lantern light.

Opaque sliding shutters (fig. 14) have the advantage that there is little to go wrong and they can be operated easily, even in high wind.

Another method (fig. 15) of installing internal wood sliding shutters has the advantage of producing a reasonably weather-tight roof covering when in the blacked-out position. This is especially useful when the roof glass is broken, as the

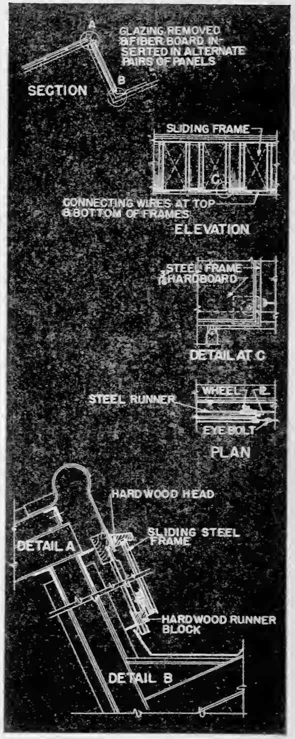


FIGURE 17.—External sliding shutter, horizontal movement.

interior of the building can then be protected from shattered glass and also from the weather until glazing is repaired.

Installations for internal sliding shutters are shown in figures 16 and 17.

Light-Locks

Light-locks are means whereby persons may enter or leave buildings during blackouts. Certain other types of similar screening devices (light traps) are also included. A light-lock consists essentially of a passage or tunnel (usually 2 feet 3 inches wide) having dark walls and ceiling, so constructed that no direct light source or light reflected therefrom is visible at its exterior entrance.

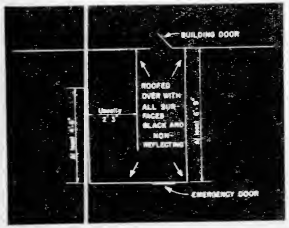


FIGURE 18.—Essential features of inside and outside light locks.

Figure 18 illustrates an inside or outside light-lock possessing these essential features, constructed so that all direct light passing through the inner entrance undergoes double reflection from its walls. However, when this construction presents difficulties, double reflection may be dispensed with and simpler arrangements adopted, provided that any sources of light near the inner entrance are suitably screened. Two doors or lightproof curtains in a passage will serve the same purpose. An emergency door for hasty direct entrance or exit should be provided, as shown, when possible.

Walls and ceiling of a light-lock usually are painted dull black. For pedestrian traffic, usually a white line over 2 in. wide is drawn horizontally along the walls at a height of 3 ft. 6 in. The floor may be any dark material that does not polish. Solid walls extend to the ceiling of the lock. Where there are steps at entrances, their edges should be dull matt (rough) white, with warning (e. g., "6 steps down") painted on the floor just inside the entrance and another (e. g., "6 steps up") at the bottom.

Partitions may be prepared in collapsible hinged sections that can quickly be erected and removed. They may be made of materials such as plywood or fiberboard, subjected, if possible, to some fire-proofing process. If used, the dead black coating is applied *after* fire-proofing treatments have been done.

Typical Examples

Entrances Frequently Used by Pedestrians to Small Buildings and Shops.—Where no part of the light-lock can be permitted to encroach on the space outside, light-locks, single type (fig. 19 (1) (2)), and light-locks, double type (fig. 20 (1) (2)), are used.

The outer wall or walls should extend beyond the central baffle by a length at least equal to the width of the passageway.

Where some encroachment on the space outside is permissible, similar locks are constructed outside instead of inside the building, or part of the lock may be inside and part outside of the building (fig. 20 (3)). If inside lights are screened so no direct light enters, baffle may be omitted.

Numerous entrances, frequently used by pedestrians, with external light-locks.—The light-locked space, common to several entrances (fig. 20 (4)), forms an arcade, preferably not less than 8 feet wide, (*A*) to allow shoppers to pass; the sidewalk width outside (*A'*) should be adequate for pedestrian traffic. Where arcades can use one-way traffic, the width may be materially reduced. During daylight, double doors (*B*) facing shop windows and end doors should be left open to provide free passage. After dark, double doors should be used only as emergency exits and opposite each shop entrance an additional emergency exit (*C*) is provided. Normal lighting may be provided within the arcade, and illuminated windows are permissible, provided light-locks otherwise satisfy the requirements outlined above. Use of this method is subject to having pavements of adequate width and consent of local authority.

Pedestrian entrances at factories and similar buildings.—When light-locks can be arranged immediately inside exit doors, methods shown in figure 19 are recommended. In other cases use of blackened corridors or simple baffle arrangements immediately opposite and within the doorway may suffice. When arrangements cannot readily be made inside the factory, a forofm external device (fig. 21 (1)) with baffles at each end may be adopted. It should be portable and roofed in but open on the side facing the factory door, so as to be removed during the day and wheeled into position covering the factory door at night. Width of passage should be not less than width of the exit doorway (*A*) and it should extend out a distance of not less than twice the width of the exit door on both sides. Interiors should be painted dull black with arrows indicating direction of movement painted in white on the wall facing the exit. Effectiveness of the arrangement is considerably increased when a short darkened passage within the factory leading to the exit door can be provided. No direct light should emerge through the exit door (fig. 21 (2)).

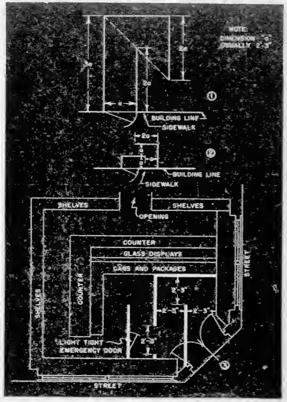


FIGURE 19.—Examples of inside single light-locks.

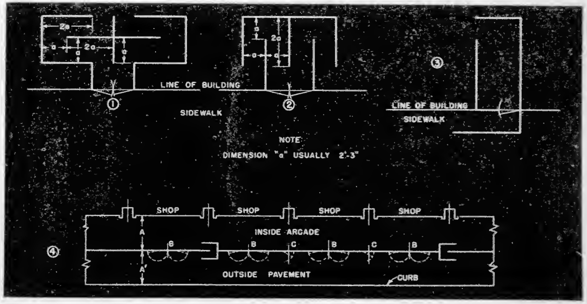


FIGURE 20.—Examples of double and outside light-locks.

Treatment of Emergency Exits

Any type of light-lock involving any obstruction to rapid passage of the public is undesirable as an emergency exit. The following will reduce to a minimum the amount of light thrown outside the building if the exit is so used after dark. Methods shall conform to the specifications and recommendations issued by the Office of Civilian Defense for exterior and interior lighting.

(*a*) All direct light from any source or reflector should be shielded from the exit.

(*b*) Any passageway approaching an exit should be lighted as dimly as is consistent with safety and walls adjacent to the exit should be painted with a dark matt paint.

(*c*) Where exits are not approached by passages, tunnels of a length not less than twice the width of the doorway should be constructed of matt black materials, immediately inside or outside the exit doorway.

Provision of Illuminated Signs Within Light-Locks

Where illuminated signs are permissible, letters or symbols forming such signs may be cut or otherwise made in the wall of the light-lock. These openings, made under expert supervision, should be covered with translucent diffusing material and placed so they receive light from inside the building and are visible from within the light-lock.

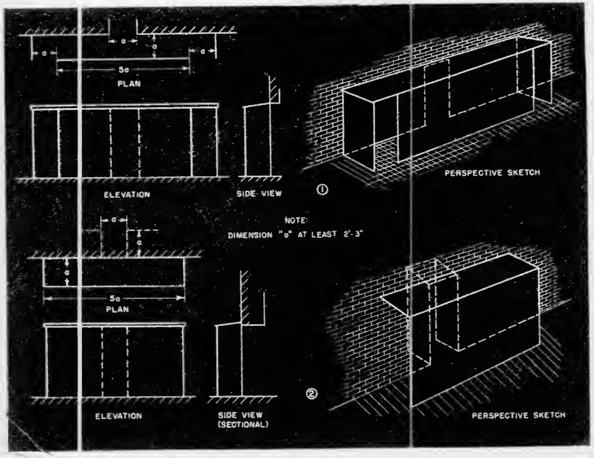


FIGURE 21.—External removable light-locks for factory use.

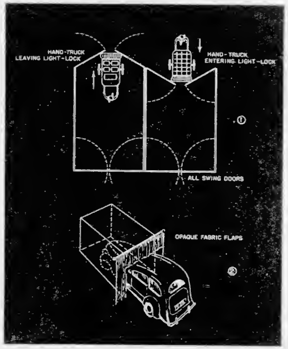


FIGURE 22.—Hand truck light-locks and portable enclosures.

Graduation of Light in the Vicinity of Light-Locks

To prevent entry of strong light into the locks, sources of light near entrances to interiors of buildings should be shielded, as recommended in the applicable specifications issued by the Office of Civilian Defense. Diminution in intensity of light in this vicinity is also necessary to lessen the contrast between bright interior lighting and relative darkness within the lock, thus aiding adaptation of the eyes to these conditions.

Other Screening Devices

Where adoption of light-locks is not convenient, as at garages and warehouses where motors and other vehicles are constantly entering, special means of blocking out light at exits must be used. All vehicles can pass through special light-locks or long covered passages that have an equivalent effect. The following are typical examples:

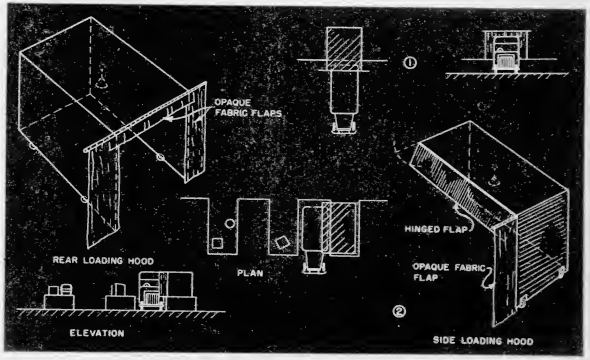


FIGURE 23.—Portable enclosures for rear and side loading of trucks.

Hand-truck entrances at factories.—For this purpose, an arrangement of two sets of double-swing doors may be effective (fig. 22 (1)).

Movable screens for use out of doors where other methods of obscuration are impracticable.—These may be complete portable enclosures in a variety of designs capable of being quickly transferred from place to place. A small and compact form of screen enables engines of motor vehicles to be examined by artificial light under a canopy (fig. 23 (2)). More elaborate forms, to facilitate loading and unloading of trucks, are used in areas where complete obscuration presents difficulties (fig. 24 (1) (2)). The above devices may not be applicable where loading is done across sidewalks between building and roadway. A double or treble row of overlapping portable screens on rollers with auxiliary curtaining, if required, will prevent any light escaping through joints or cracks while the truck is being loaded and allow for adjustment of the screens to block any escape of light when the truck is removed. (See fig. 24.)

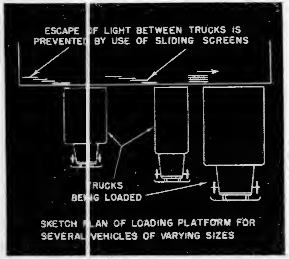

ESCAPE OF LIGHT BETWEEN TRUCKS IS PREVENTED BY USE OF SLIDING SCREENS
TRUCKS BEING LOADED
SKETCH PLAN OF LOADING PLATFORM FOR SEVERAL VEHICLES OF VARYING SIZES

FIGURE 24.—Use of portable screens for loading all kinds of trucks.

Glow From Industrial Processes

There are many processes in industry that produce a glow, reflected light, or flames visible outside the plant buildings. Steel mills, foundries, sugar refineries, oil fields, oil refineries, brick and ceramic operations, sawmills, gas plants, and the like are examples. In addition to the actual operations producing the light, there are secondary examples, such as slag piles.

As much time as is possible should be secured to permit the control of the various processes and to prevent the glow; and it is most important that arrangements be made to secure the preliminary air raid warnings.

Below are listed some of the typical examples of equipment used in many steel mills and foundries that must be given serious consideration with regard to eliminating all light source during a blackout.

Blast furnaces.—The modern double-bell type of blast furnace does not give off any light during the charging operation, but there are still a few single-bell type blast furnaces that give off light during the charging operation. Any blast furnace will give off light after tapping and during the casting operation.

Bessemer converters.—All Bessemer converters give off a great amount of intense light during the blow operation, which has a time cycle of approximately 10 to 20 minutes.

Open-hearth and reverberatory furnaces.—Open-hearth and reverberatory furnaces usually show some light and even flames through the stacks and after tapping the casting operation gives off considerable light.

Cupolas.—Cupolas give off light and occasional flames throughout their entire operation after tapping and considerable light, flame, and sparks immediately after dropping the bottom.

Ingot-stripping and ingot-soaking pits.—Red-hot ingots stripped from ingot moulds give off light during the stripping operation and during the period of the subsequent cooling. Ingot-soaking pits give off light during the period of loading and unloading the pits, and the hot ingots removed from the soaking pits give off a considerable amount of light.

Rolling mills.—The heating furnaces used in rolling mills for heating billets and ingots produce considerable light when the furnace doors are open for charging and discharging.

The hot billets and ingots produce light during the rolling operation until such time as the rolled sections reach the hot beds, where they cool down rather rapidly.

Beehive coke ovens.—Beehive coke ovens give off considerable quantities of gas flames at the top of the ovens and there is additional reflected light around the base through the checkered air inlets.

Byproduct coke ovens.—Byproduct coke ovens produce light during the charging and pushing operations and additional light may result from gas leaks around the door openings, caps, lids, and covers.

Practically every one of the foregoing processes gives off certain characteristic lighting that can be readily identified from the air, thereby denoting the general nature of the operations. It is, therefore, important that these characteristic light sources be obscured during a blackout period, so as to eliminate "landmarks" that might aid enemy planes in the identification of a local area.

Suggested Methods of Preventing Glow

Generally, there are few mechanical blackout devices that can be applied to industrial operations producing reflected light, glow, and flame. The problem is further complicated by the type of local installation and methods of operation. It is possible, however, upon a thorough study of the local operations, to adjust operating conditions or to apply certain methods of operation that will usually eliminate all such light sources during the time of actual air raids. An attempt to control these operations over extended periods of blackout, as all night long or continuously night after night, would, of course, necessitate a complete blackout plan or a permanent shutdown in many instances. This is particularly true of all coke-oven operations, many open-hearth operations, and all Bessemer converter operations. On the other hand, by completely housing many of the operations so that there is no light visible to the outside from within the housed equipment, operations can be carried on continuously. Typical examples of this would be cupola operations in the foundry or double-bell blast furnace operations where it is not necessary to transfer ladle cars of hot metal outside the buildings.

Blast furnaces.—Glare resulting from the charging of single-bell type blast furnaces can most successfully be dealt with by stopping the charging operations during a blackout.

Bessemer converters.—In case of a blackout warning, and sufficient time permitting, the blow should be finished, the heat of steel poured, the converter turned nose down, and the operation stopped until the emergency is over.

Open-hearth and reverberatory furnaces.—Open-hearth furnace operations that produce a glow in the stack can be obscured during a blackout by running a reducing atmosphere in the furnace and smoking up the chimney sufficiently to eliminate the glow. If a blackout occurs when an open-hearth furnace is ready for tapping, it may be advisable to delay that operation.

Cupolas.—Flame and glow from cupolas can be eliminated by the use of an oblique refractory arch through the cross-section of the cupola stack and bypassing around the arch, thereby obscuring the light source. Ordinary roofing tar may be thrown on top of the charge in the cupola to create sufficient dense smoke to hide any flame or glow and permit the cupola to operate in a very nearly normal manner.

Ingot-stripping and ingot-soaking pits.—Ingot-stripping and soaking-pit operations can be stopped during a blackout so as to eliminate the light or glow.

Rolling mills.—Rolling-mill operations can be temporarily obscured if the building is not equipped for blackout by stopping such operations as the charging and unloading of heating furnaces and the rolling process during the blackout but permitting steel already in the rolls to be run out.

Beehive coke ovens.—Light from beehive coke ovens is extremely difficult to obscure. The reflected light from the checker work air inlets at the base of the ovens can be covered up, but there is no satisfactory way of eliminating the gas flame at the top of the oven. A shedlike construction over the gas outlet may help to some extent.

Byproduct coke ovens.—The light from byproduct coke ovens can be eliminated during a blackout period by stopping all charging and pushing operations, making sure that all gas leaks around the ovens are stopped up with fire clay and that all standpipe caps, charging hole lids, and inspection-hole covers are tightly in place to prevent any gas leaks that might ignite.

Gas producers are commonly used in many industries and sometimes give off light. During a blackout period, the steam and air supply can be reduced and the operations suspended.

In blast or open-hearth furnace operations the hot ladles of metal give off considerable light. During a blackout period, the top of the metal in the ladles may be covered with coke and the ladles kept under cover; likewise with cinder or slag ladles.

The slag dump from a blast-furnace operation may give off considerable light immediately after the dumping of hot cinder or slag. Cars of sand may be kept ready to throw over the red hot slag in case of a blackout. Water for quenching slag heaps may also be used, although it is usually difficult to get water to the average steel mill slag dump.

Gas purge pipes from byproduct coke-oven operations, oil fields, oil refineries, and other similar operations should be carefully studied for the proper means to be employed for extinguishing the flame and discharging the gases high enough above the ground so as not to have the gases blow back into occupied areas and affect the health of employees or cause a fire or explosion hazard. Purging of raw gas to the atmosphere should be done at a height of from 150 to 200 feet above the ground, utilizing an old unused chimney if possible. Such raw-gas discharges may become ignited during an electrical storm and means should be provided for shutting off the gas flow if that should happen.

Burning refuse piles at sawmills should be extinguished with water in case a blackout is ordered.

Careful study of the local situation is necessary in planning the obscuration of operations that normally give off light. Much can be done to house the operations more thoroughly. Light-locks in the form of louvers can be used around ventilating openings and entrances to buildings.

Operations can be adapted to short blackout periods, but the problem becomes greatly involved, even to the extent of shutting down, if long blackout periods are ordered. The solution proposed for each plant or operation should be tested repeatedly to determine its adequacy for the protection required.

TREATMENT OF GLAZED SURFACES

General

In order that the normal activities of life may be carried on inside buildings, glazed areas are installed. The amount of the surface area of any building that is glazed depends, in a large measure, upon climate and the character of the activity to be carried on within. In preparation for blackouts, some glazed openings may be obscured permanently, but others must be left undisturbed so that daylight may enter the building. At night, however, these latter areas must be capable of being rapidly obscured. These considerations must be kept in mind in preparing for blackouts. In addition, glass when suddenly broken, as by an explosion, creates a highly dangerous splinter hazard.

Strength of Glass

All glasses of normal commercial thicknesses, whether sheet, plate, or wired, are liable to be broken by intense blast effects within about 200 feet from any high explosive bomb. At greater distances chances of breakage depend, apart from the size of the bomb, upon a number of factors, such as strength of the glass, size of panes, methods of placing, rigidity of the window frame, whether the window is open or closed, and degrees of protection afforded by adjacent walls. It is, therefore, possible only to approximate the extent of area in which glass may be broken as about 150 times larger than the area of intense blast effect. The devices for preventing scattering of glass described below, although intended primarily to deal with damage by distant effects, are nevertheless effective in many cases under more intense blast pressures, even within a radius of 200 feet from a bomb. Within this inner area many windows are likely to be subjected to blast alone, bomb fragments being stopped by obstructions; outside that area damage by fragments will be comparatively rare. Therefore, the devices take no account of bomb fragments, even at long range, and are suggested for use in rooms, such as offices, stores, etc., where the contents are not of special value and where the entry of one or two chance fragments is not important.

Glass Installations

To determine whether one type of window glass is more resistant than another is almost impossible, except in very general terms, as there is considerable variation in the strength of glass, even of panes cut from the same sheet. However, the following should be considered.

If a double-hung sash window is about one-third open, the panes are less likely to be broken than if the window is shut, because there is a better chance of the blast acting on both sides simultaneously. Risk of damage is probably less in casement windows, which should be completely open.

A semi-rigid fastening is better than a rigid one, because the window as a whole can more readily vibrate with the blast wave. For instance, an unfastened sash window that is a loose fit in its runners, or a casement window held by a loose-fitting peg stay or by a sliding stay, usually has some freedom of movement. However, violent vibration of the window as a whole may result in breaking of the glass. Glazing in a door that is open, or glass held in rubber or felt strips, has a somewhat better chance of survival than more rigidly held panes. When leaded lights or panes of flexible glass substitutes fail, they usually do so bodily, falling out as complete units, sometimes with little damage to the glass itself.

Where glass is strong in relation to the frame, the latter may be forced out, the glass sometimes remaining unbroken. This may occur in windows divided by numerous glazing bars into small units or where thick glass is held in slender steel or bronze frames.

Wired glass is about as easily broken by blast as unwired glass in equivalent sheets, but it does not, however, fly so readily into small dangerous splinters.

Panels of glass bricks of about 75 sq. ft. superficial area held in a light framework of reinforced concrete offer very considerable resistance to blast. Where they can be protected against bomb fragments, they may be expected to withstand blast even as near as 50 feet from a bomb, unless they are used in exceptionally large areas.

Glazed partitions and door transoms inside buildings may be broken where external windows remain undamaged because left open, or where external windows, left closed, suffer no more damage than frame buckling and dislocation of the glass.

Glass Protection Against Distant Effects

1. *General.*—Beyond about 200 feet, the intensity of blast and the chance of glass breakage decrease rapidly for bombs generally used. The ability of glazing to withstand blast pressure in this general radius will depend on the type of glass, its setting, thickness, and size of panels, and the degree of protection offered by adjacent walls and other objects. The vibration frequency plays an important part in the ability of glass to resist breakage. The unusual nature of blast effect is demonstrated by the fact that windows have been completely shattered 200 yards from a bomb explosion while windows considerably closer and more exposed were unharmed.

2. *Windows.*—Window frames with glass protected by laminated sheets of cellophane, with laminated glass, and with a plate of steel protecting the glass have been subjected to intense blast pressures and in no case has it been possible to preserve the glass.

The best precaution is to remove the window, and, if not, to open it and then provide a light frame covered with heavy reinforced paper or similar material, which can be lightly wedged into the window opening so it will be dislodged when subjected to blast pressure and then may readily be put back again.

3. *Roof lights.*—Roof lights and ventilators present a source of considerable danger because they are not only subjected to blast and hits by bombs but are exposed to falling fragments of bombs and antiaircraft shells as well. The destruction of overhead glazing also adds the immediate problem of weather protection and obscuration of light. The importance of glass protection is emphasized by the fact that there have been instances of serious delays in industry because of shattered roof glass when other damage was insignificant. Protective methods cover a wide field with numerous degrees of protection, and the type of protection to be used will be determined necessarily by individual requirements.

4. *Methods of protection.*—Protective measures are discussed below and include ventilation, protection from flying and falling glass and from the weather after glass is broken, and obscuration and the maintenance of obscuration when glass is broken.

a. *General.*—Glass is used extensively for vertical and roof lights in all types of buildings and industrial plants. Vertical windows may be protected up above the height of machinery or other contents of the building, and in any event not less than 6 feet above the floor, by blocking.

(1) *Permanent obscuration.*—In cases where permanent obscuration is not objectionable, the glass may be coated or removed and the following materials used

(*a*) *Roof glazing.*—The glass may be treated externally with fabric net or any type of cloth and reasonably heavy bituminous emulsions. In addition, the glass also should be supported by wire mesh attached close underneath. This method will give weather protection as well as maintain the efficiency of blackout after the glass has been fractured.

Where the glass has been removed, composite sheets of asbestos and steel or hard wallboards may be substituted. These materials will withstand blast pressures considerably greater than those that fracture roof glass. When displaced, they can usually be replaced still intact; also, they can be anchored in the same way as roof glass.

Thinner and more flexible materials, such as combinations of wire mesh and roofing felt and soft wallboards, will probably require supporting underneath with wire mesh netting or transverse supports.

Flat and corrugated asbestos-cement sheeting is readily fractured by blast. Therefore, there is little to be gained by using it as a substitute for roof glazing, as it is likely to be shattered before it is displaced. However, it may be used in walls.

Wallboards require painting or impregnation with preservatives to give protection against weather by precluding warping.

(*b*) *Vertical glazing.*—The above-mentioned methods described as suitable for roof glazing can also be used in windows. In addition, bituminous sheeting and plywood can be used. The latter two should be painted on the face and on the edges to prevent the soaking-in of moisture. Firm anchoring, such as nailing, is not desirable. The materials should be held in place by the same methods as those described below, parts I and II, for the flexible substitutes for glass.

(2) *Retention of daylight.*—If light requirements make essential the retention of glass in the window, one of the following steps may be taken:

(*a*) Remove the glass and substitute laminated glass, which should be $\frac{3}{16}$ inch thick for panes no larger than one square foot and somewhat thicker for larger panes. Laminated glass will withstand blast pressure if securely set in the frame, and, although it may crack, the plastic sheets within the glass will keep the window gasproofed.

(*b*) A flexible substitute for glass may be installed. This should be reinforced by $\frac{1}{2}$-inch mesh wire securely fastened to the frame and in contact with the inner surface of the material. This type of protection will withstand considerable blast pressure if properly anchored. If the material is anchored or attached with nails or staples, it will tear at the edges when it is displaced by blast. In addition, if anchored too strongly, it may break in the center. The following methods of anchoring are suggested:

(I) *Wood windows.*—The material may be attached on the face of the frame by plasterer's lath or similar wood strip. In such a case, care must be taken that the nails or tacks used to secure the laths do not perforate the edge of the material.

The edges of the material may be fastened to the frame by means of adhesive tape.

Ordinary wood glazing beads in the glass rebates may be used for holding the material in place. Care should be taken that the material is not bent around the beads.

(II) *Metal windows.*—The material can be set in a soft nonsetting putty or mastic, preferably one that can be scraped off and reused.

b. *Adhesive treatments on glass.*—Various methods of covering glass with the aim of minimizing the scattering effects of blast lend themselves to effective use. Several methods consist of the use of sheets of material cemented to the glass with an adhesive or a liquid material applied with spray or brush. It should be distinctly understood that these treatments will prevent glass from flying in splinters but cannot be relied upon to prevent breakage. However, these materials will reduce extensive breakage by distant blast effects. In selecting a window treatment to reduce the effect of splintering, the following should be considered:

Tensile strength or extensibility.

The material should adhere strongly to the glass.

Both material and adhesive should retain their properties for a reasonable time under exposure.

The material, applied to the inside of the glass, may be in sheets; it is desirable to render the glass nonreflecting, especially in the case of roof lights.

The following materials may be considered for use on glass:

(1) *Paper.*—Papers that are thick and tough are preferable to thin papers. Papers reinforced with a mesh of cotton, linen, hemp, or other fiber are superior to other types.

Flame-proofed papers, if available, should be used.

It is important that the adhesive should remain tacky and not become brittle after being applied. Suitable adhesives are an ordinary flour paste or paperhangers' paste.

(2) *Textile materials.*—Textile materials used as an all-over coating consist of two types: Those which give permanent obscuration and those which admit a certain amount of light. The former may consist of burlap pressed into a bituminous emulsion painted all over the glass. This provides complete obscuration and offers good resistance to splintering.

An adhesive treatment for plate glass consists of a full coat of a good "long" varnish or synthetic coating brushed on the glass and over the frame. When the varnish has become tacky, a sheet of fabric or strong textile netting should be pressed into the varnish so that the whole glass area and frame have been covered. After the material has thoroughly set, a full coat of varnish should be applied. This method will serve to minimize the scattering effect for glass $\frac{3}{16}$ or $\frac{1}{4}$-inch thick. However, the translucency will be considerably lessened.

(3) *Transparent wrapping films.*—Materials of this type usually admit a large proportion of light but are not generally as resistant to splintering as the textile materials when the latter are properly applied. Some transparent fillers, however, are reinforced with fabric mesh that improves their strength.

(4) *Cellulose acetate film.*—This is a slow-burning film. Gum is not suitable for application. If an adhesive is not recommended by the manufacturer, a mixture of rosin and castor oil in a thick paste, thinned with wood alcohol, or a mixture of 9 parts of molasses and 1 of warm water may be used. Unless this film can be obtained in thicker sheets than that generally used for wrapping, several layers should be used. In applying, a roller or straight edge should be used, starting at the top of the pane. Where the glass has been fractured or dislodged, a cellulose acetate film, reinforced with fine wire mesh, will provide a translucent flexible substitute material for glass. The wire mesh should be coated or impregnated with the cellulose acetate. The methods for applying the sheets to the window are the same as those previously described for flexible substitutes for glass. For transparency, the use of pure cellulose acetate sheets adhered securely over the entire area of the glass and the frame has proved satisfactory.

(5) *Adhesives.*—An important requirement of adhesives is that they should not dry out and become brittle; the addition of glycerin will prevent this. Glass should be thoroughly cleaned before the application of adhesives and special

care should be taken to remove all grease. Of the flexible glues, a suitable type for hot application is "bookbinders' glue." Of the pastes, the ordinary paperhangers' paste with molasses added is the most suitable. Sodium silicate ("water glass") should not be used as an adhesive, as it is liable to damage the surface of the glass.

In general, some additional resistance to splintering can be obtained by coating the outside as well as the inside of the glass.

In the case of roof lights, the material may be applied to the outside. Burlap applied with a bituminous emulsion resists weathering and is effective for such use.

(6) *Liquid coatings.*—Many varieties of liquid coatings are being studied, but no definite conclusive tests have been made that indicate the suitability of that type of treatment. Tests of liquid coatings to prevent scattering of glass are being conducted, but the results are not yet conclusive.

All such coatings should be tested, before adoption, to determine if the coating presents a fire hazard.

It is impossible to predict the probable effective life of these coatings under various conditions. When evidence of deterioration occurs, the old coating should be removed immediately and replaced.

In applying liquid coatings, care should be taken that they be put on smoothly, avoiding vertical or horizontal brush lines where some degree of transparency is desired to be retained. Some compositions, unless put on flatly in the first instance, may not smooth themselves out in the ordinary spreading and drying process.

c. *Additional protection.*—All glass may be further protected by chicken-wire mesh not larger than ½-inch to prevent flying splinters. The mesh should be installed as close as possible to the inside surface of the glass. If attached to the window frame, the wire will prevent cleaning or reapplication of the treatments outlined above. The netting is therefore best attached to a separate frame fitted snugly in against the window. A curtain or screen may then be attached to the opposite side of the frame and will offer reasonable protection from weather if the glass is destroyed.

APPENDIX I

General Suggestions for Conduct of Employees

Plant

1. Comply immediately with all directions given by Air Raid Wardens.

2. Cooperate in keeping aisles, exits, and surroundings free from obstructions. Good housekeeping is always an aid to safety, especially in an emergency.

3. Avoid spilling anything on the floor. Someone may stumble or slip and fall.

4. When working in elevated locations, such as on ladders, stairways, scaffolds, runways, platforms, balconies, roofs, or other elevations, leave them carefully and by the safest and most convenient manner. Undue haste may cause some elevated structures and objects to collapse or be thrown over.

5. Know in advance exactly *what* you will do in an emergency. If it is necessary to leave your work, leave it in a condition that will provide safety and economy, just as should be done when ceasing work for the day.

6. Familiarize yourself with the locations of the stairs, fire escapes, doors, passageways, and elevators that you will use for emergency exit; their convenience, capacities, and your chances of using them promptly. This is especially important for those employed in basements or above first floors. When going to the emergency shelter, avoid areas of the plant ordinarily considered dangerous.

7. Avoid carrying tools with you, especially sharp edged and pointed tools. Put your tools away carefully.

8. When leaving your workplace suddenly, do not upset, scatter, or otherwise disturb materials and products.

9. Do not rush ahead of others. Coolness and orderly movement is safest and will aid in avoiding dangerous jams and "bottle-necks."

10. Be prepared to assist others.

11. Do not joke about the problem of emergency or its necessities. Think of it as serious business in the interest of the well-being of yourself and others.

12. Be alert to acts of sabotage.

13. Specially designated employees will take emergency stations to provide previously arranged protection for machines and finished materials.

Office

1. Shut off electric fans, heaters, and air-conditioning equipment.

2. Be prepared to put quickly in a safe place all cash, currency, securities, secret papers, and other documents or papers of unusual value.

3. Practice leaving in the safe or vaults as much as possible of the books or materials ordinarily stored there over night.

4. Loose papers on desk tops should be weighted, placed in desk drawers, or otherwise cared for.

APPENDIX II

Incendiary Bombs

The most common type of incendiary used in the present war is the 2.2-pound magnesium bomb, although larger sizes are sometimes used. A bombing plane carries 1,000 or 2,000 bombs, the number depending upon its size and the distance to be traveled. It is estimated that between 10 percent and 15 percent of the bombs dropped strike buildings, and that about half of these start fires. When a bomb strikes a roof, the penetration depends on the roof slope and the angle of impact of the bomb itself. Incendiary bombs will readily go through an ordinary plank roof and may penetrate several inches of concrete.

The common bomb so far used is a magnesium shell, about 2 inches in diameter, 9 inches long, and ⅜-inch thick, with a sheet-iron tail-piece about 5 inches long. It is filled with thermit, a mixture of iron oxide and aluminum powder. There is a fuse in the nose which ignites on impact, causing the thermit to burn fiercely, with the result that the whole magnesium shell burns with an intense fire until it is totally destroyed. In the first half minute or so, bits of molten metal shoot out through vent holes to a distance of 10 feet or more. If left alone, the bomb will burn for 10 or 15 minutes, until it is consumed.

To put a bomb out of action, shoot a jet of water directly at it without delay. There will be a burst of white flame and a scattering of metal when the jet hits the bomb. There is little personal danger, however, as the force of the jet will drive most fragments away.

As soon as the jet has struck the bomb, there is little left of it except the unburned part and the scattered fragments. Quick use of the jet will quench these and any fires that have been started.

Before leaving the scene, one should be sure that all fire is out and that there are no smoldering embers to start another fire.

A course spray should be used only where scattering of the metal must be avoided. This will be necessary where there are quantities of materials nearby that catch fire easily. In such cases, one should wait until the bomb starts to burn quietly before attacking it. A jet of water may be directed from any small hose line, such as garden hose, from a pump tank extinguisher or a stirrup pump, from a soda-acid extinguisher, or from other like means.

If only sand is available, it should be used in the form of a mat for the purpose of covering the bomb, thereby preventing the spreading of fire. However, do not put sand on a bomb and leave it unattended.

Automatic sprinklers have been found to be very effective in controlling and extinguishing incendiary bomb fires when water supplies are not impaired. They apply water immediately and keep the surroundings from burning. Each sprinkler is, therefore, an "automatic fire spotter," and it is of vital importance to keep automatic sprinklers in service.

Some sprinkler systems may, of course, be put out of service if explosive bombs are dropped along with the incendiaries. The sprinkler piping may be broken in buildings that are struck, or, if water supplies are crippled by broken mains, the sprinklers will be temporarily without water. Then, in the case of fires started by incendiaries, the main reliance must be on quick extinguishment when the bombs land and, in the case of fires started by explosives, on fighting the resulting fires with hose streams and emergency water supplies. In city properties where sprinkler shut-offs are located in flush valve-boxes in the street, the necessary wrenches should be kept available for quick use if needed.

Magnesium bombs landing on wet surfaces burn rapidly, develop intense heat, and may even react with the water explosively. For example, such a bomb falling on a damp concrete floor may produce some "pops" that throw burning magnesium over a radius of 10 or 15 feet, thus endangering near-by combustibles more seriously than if a bomb fell on a dry wooden floor. If the concrete floor is dry, it is generally safe to let the bomb burn itself out, providing there is no combustible material nearby to be ignited by the molten globules thrown off by the bomb. A bomb landing on a heavy wooden floor may ignite it or simply char the planking. It will burn through the ordinary ⅞-inch board floor.

A percentage of the incendiary bombs used contain an explosive charge which scatters metal at high speed for 50 to 60 feet, the purpose of which is to discourage approach to the bomb for fire fighting. This means that in fighting bombs men should shelter themselves behind a solid wall or object affording equal protection during the early stages, while directing the jet of water on the bomb.

Extinguishers for Magnesium Bombs

A garden hose is very effective in extinguishing incendiary bombs so long as it is provided with a water supply; it can extinguish a considerable fire. However, the water supply may be out of service as a result of broken mains or heavy drafts elsewhere. Therefore, it may be advisable to provide emergency equipment that can be used if the water supply fails. A stirrup pump draws from a pail or container of water and discharges through a length of hose that one man can carry into places difficult to reach, while a second man operates the pump and a third keeps the container filled from some other source. A pump tank is somewhat similar, being a self-contained unit of pump and container, usually of 4-gallon capacity and supplied with a few feet of hose.

It is also possible to use any of the common extinguishers that discharge streams consisting wholly or largely of water, such as the soda-acid or gas-cartridge-operated extinguishers. Foam extinguishers should be available where bombs may start fires in flammable liquids and can be used on the bomb itself, using the stream and building up a mass of foam around and near the bomb, gradually covering it. Extinguishers that discharge vaporizing liquid (carbon tetrachloride), carbon dioxide, and dry chemical powders have no effect on the magnesium bombs themselves, but may be used on fires for which they are adapted and which start in the vicinity of the bombs.

Other Types of Incendiaries

There are many other types of incendiaries. Some of these may contain explosive charges of considerable force. Thermit, oil, and phosphorus are effective incendiary agents.

Thermit Bombs

Thermit is the igniting mixture used in magnesium bombs. Its action is violent but is all over in a very short time, not much more than a minute. Bombs of thermit alone consequently have to be much larger than the magnesium type, sizes likely to be encountered weighing about 33 to 132 pounds. The thermit reaction is virtually uncontrollable, but by the time fire fighting measures can be brought to bear the result will be simply an ordinary fire.

Oil Bombs

Incendiaries containing oil in liquid or jelly form are sometimes used. 25-pound and 100-pound bombs are common sizes. The resulting fire is an oil fire and may be controlled like any fire in an oil or gasoline spill—for example, with a foam or carbon dioxide type extinguisher.

Phosphorus Bombs

White phosphorus is a relatively low temperature incendiary, but it may be used for setting fires in grain fields, forests, and buildings with combustible roof coverings. A common bomb of this type weighs about 30 pounds. On impact it will spread small pieces of white phosphorus over an area of from 50 to 100 yards in diameter. Water easily knocks down these burning fragments, but as soon as the water evaporates the dry phosphorus reignites. Phosphorus on the skin causes a bad burn, so that fragments from these bombs should not be touched with the bare hands. A copper sulphate solution is the best treatment for phosphorus burns. As soon as the burning phosphorus is controlled by water, the particles should be collected and removed to a safe area, where their reigniting will not cause damage.

It is to be expected that the enemy will use new types of bombs and we must be ready to adopt new methods to meet these new dangers.

APPENDIX III

Protection Against Gas

Protection against gas in the industrial plant cannot be treated as an isolated problem. Measures directed toward protection of personnel from the effects of high explosive bombs may, with minor adaptations, serve also to provide protection against gas.

Protection against gas in the plant depends upon the following:

1. The appointment of a Plant Gas Officer to direct gas defense in the plant. The Plant Gas Officer should have a knowledge of chemistry and should be a member of the staff of the Plant Defense Coordinator. He should appoint deputies from each shift so that one representative will be on duty in the plant at all times.

2. Special training of plant medical, nursing, and first aid personnel in the management of gas casualties.

3. Installation of bathing facilities, especially shower baths, in large numbers and well distributed over the property. Additional showers should also be provided in the area around the plant property.

4. Provision of air raid shelters with gas locks at all entrances and provision for sealing windows and other openings through which gas could be admitted.

5. Provision of a sufficient number of gas masks to protect the members of the plant protection services.

6. Organization and training of plant decontamination units which would function should the area be contaminated with persistent gas.

7. Development of gas discipline in the employees of the plant by educational lectures, pictures, demonstrations, etc.

The above program should be instituted in all plants located in the target areas and in the designated strategic areas in the interior part of the country. Should the military situation change, additional protection for employees may be required in plants. Such additional protection might include:

1. Provision of gas mask protection to all personnel in certain plants. While this would not prevent injury to the skin from vesicant agents, it would protect the eyes and respiratory tract.

2. Installation of collective protectors in selected facilities such as telephone exchanges, Plant Control Rooms, and power plants where personnel would be required to remain on duty during an attack.

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A Suggested Bulletin Board Poster:

WHAT TO DO IN AN AIR RAID

For Workers in Industrial Plants

Remember that this is a *War of Production*. Your work must continue every possible minute. Special precautions have been arranged for this plant to enable you to do this and have the maximum protection.

FOLLOW THESE DIRECTIONS

ON THE ALERT:

1. Those assigned to defense posts go to them at once (Plane Observers, Fire Watchers, Wardens, etc.).
2. Those assigned special duties perform them at once (Valves, Switches, etc.).
3. All others remain at work. Keep calm, set an example.

ON THE SOUND OF THE ALARM:

1. Take all necessary safety measures for your machine and tools.
2. Go to your designated safety area.
3. Wardens will turn out lights if building is not blacked out.
4. Remain alert, ready to help fight incendiary bombs or assist others if needed. If not needed, keep under cover.
5. When the "all clear" sounds, return at once to your work.
6. Do not try to telephone home—phones are needed for emergency use. You can help the folks at home most by keeping calm where you are.
7. Know your Air Raid Warden and follow his directions.

The Alert Signal is: (Imprint local signal.)
The Alarm Signal is: (Imprint local signal.)
The All Clear Signal is: (Imprint local signal.)

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